Brainstem
Blood supply - Arteries

4th ventricle
Cerebellum

Neuroanatomy notes for Excellent students by David

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By: Adi, Antal, Dana, David, Ido, Irit, Jesus, Klara, Liat, Magal, Mor, Noa, Ofer, Peter, Zoli (the bad one).

Please notice –

- these notes do not include the required knowledge for the physiology, biochemistry and histology. It only includes everything you need for the anatomy exam.
- these notes are based on the books Hain's, Barr's and Snell's, on Dr. Najeeb videos, on lectures and teachers' remarks from the practice room, and from other videos.
- Neuroanatomy has infinite number of details, and many things are not yet well known. These notes are the outcome of combined effort of many excellent students. They do not include all the information from the books, but they will certainly enable you to get the best score in your exam, and sometimes they are more detailed than necessary.

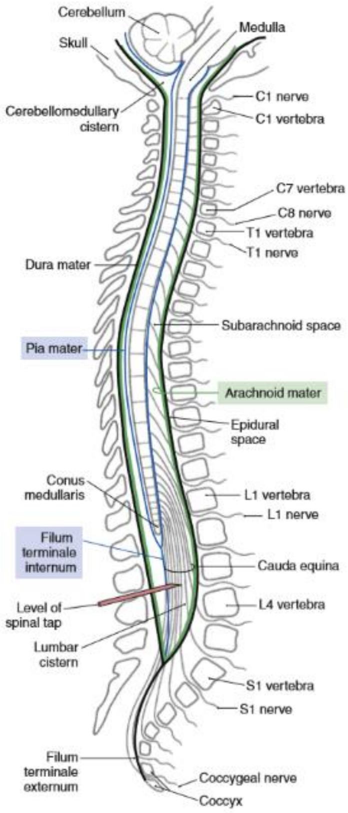
Good Luck and do your BEST!

David Carmon

Group A

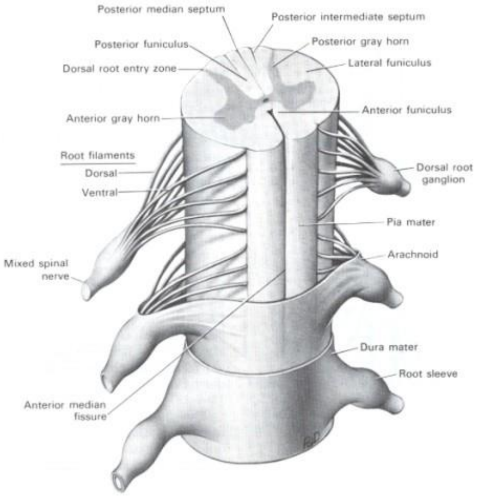
Topic 1 – Surface anatomy of the spinal cord. The spinal nerve and its roots

Hain's 124.


Cerebellum
Skull
Medulla
C1 nerve
C1 vertebra
Cerebellomedullary cistern
C7 vertebra
C8 nerve
T1 vertebra
T1 nerve
Dura mater
Subarachnoid space
Pia mater
Arachnoid mater
Epidural space
Conus medullaris
L1 vertebra
L1 nerve
Filum terminale internum
Cauda equina
Level of spinal tap
L4 vertebra
Lumbar cistern
S1 vertebra
S1 nerve
Filum terminale externum
Coccygeal nerve
Coccyx

Gross appearance:

- Shape: Cylindrical
- Borders:
  - superiorly – medulla of brainstem, at the level of foramen magnum.
  - inferiorly – Terminates at L1, in a young child it terminates at upper border of L3. Its fibers continue downward as cauda equina.
- Occupies upper 2/3 of vertebral canal. In beginning of development they are equally long but the vertebrae grow faster, so the vertebral canal is longer.
- Surrounded by the meninges: dura, arachnoidea & pia mater, and CSF in the subarachniod space.
- Cervical and lumbar enlargements (intumescence): bigger anterior horn of gray mater, because it gives nerves to limbs thru the brachial and lumborosacral plexuses.
- Conus medullaris: inferior end of spinal cord, becomes narrow like a conus. at the level of L1-L2 in adults.
- Filum terminale internum: prolongartion of the Pia mater inferiorly from Apex, attaches to the end of dura mater. The dura attach the coccyx – filum terminale externum.
- Denticulate ligament: formed by pia mater. From each level of the cord, About 20-22 small strings adher laterally to arachnoid and dura mater. They stabilize the cord.
- Cauda equina: inferior to the end of spinal cord, lumbar and sacral spinal nerve continue downward. found in the Lumbar Cisterne (a subarachnoid space).


Posterior median septum
Posterior intermediate septum
Posterior funiculus
Posterior gray horn
Dorsal root entry zone
Lateral funiculus
Anterior gray horn
Anterior funiculus
Root filaments
Dorsal
Ventral
Dorsal root ganglion
Pia mater
Arachnoid
Mixed spinal nerve
Dura mater
Root sleeve
Anterior median fissure

The inside Structure of the spinal cord:

- Composed of inner core of Gray matter, surrounded by white matter, the segmentation is not seen on gross appearence.

1. Gray matter:
   - H-shaped pillar with anterior and posterior horns (columns) united by a thin gray commissure in the middle, in which a small central canal is found. Anterior horn is motor, and posterior horn is sensory. Each is divided to few histological lamina that are not mentioned in these notes.
   - The amount of gray matter is related to the amount of muscle innervated at that level. For that reason there are cervical and lumbosacral enlargements, that give nerves to the upper and lower limbs.
   - the central canal is found in the center of the gray matter. It is filled with CSF and continues superiorly with the 4th ventricle.
   - Ventral horn – motor neurons (SM). Its narrow at thoracic level and enlarged at cervical & lumbar level (due to the plexuses).

- Lateral horn – only at the level of T1-L3. visceromotor (VM) neurons, that give preganglionic myelinated fibers that pass therough white communicating rami to the **sympathetic ganglia**.
- Dorsal horn – somatosensory (SS) and viscerosensory (VS).

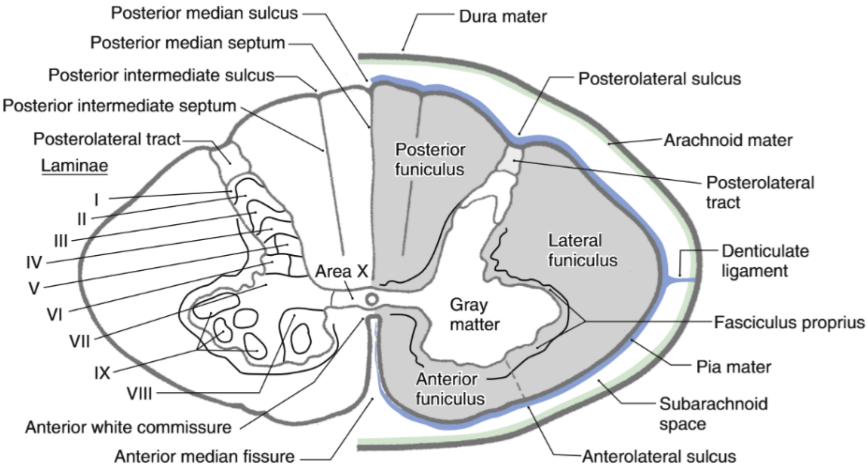
The gray matter is a mixture of nerve cells and their processes, neuroglia and blood vessels. The nerve cells are **multipolar**.

2. White matter:

- Through it the axons ascend or descend.
- Descending pathways: Axons that descend from the brain to the spinal cord. These are **efferent** fibers that effect the target tissue.
- Ascending pathways: Axons that ascend from the spinal cord to brain. These are **afferent** fibers that send information from sensory cells to the brain.
- The axons of these pathways pass through one of 3 areas, called funiculus – posterior, lateral and anterior funiculi.

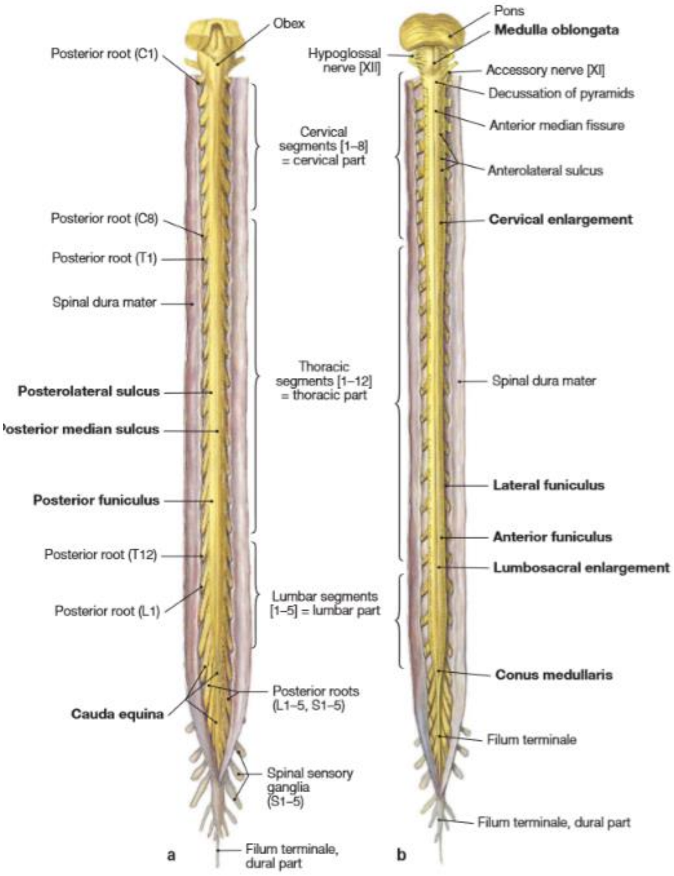
external surface of Spinal cord: On the surface of the cross section we can see few sulci:

1. Posteriorly – 3 sulci. They are close, so it helps to identify the posterior part of spinal cord:
   - Posterior median sulcus – not deep.
   - posterior intermediate sulcus – on the 2 side of posterior median sulcus. Between gracile and cuneate.
   - Posterolateral sulcus (dorsolateral sulcus) – entrance of dorsal root (sensory fibers) from DRG. Posterior spinal artery passes medial to it.


Posterior median sulcus
Posterior median septum
Posterior intermediate sulcus
Posterior intermediate septum
Posterolateral tract
Laminae
I
II
III
IV
V
VI
VII
IX
VIII
Anterior white commissure
Anterior median fissure
Dura mater
Posterolateral sulcus
Arachnoid mater
Posterolateral tract
Posterior funiculus
Lateral funiculus
Area X
Gray matter
Denticulate ligament
Fasciculus proprius
Anterior funiculus
Pia mater
Subarachnoid space
Anterolateral sulcus

Anteriorly –

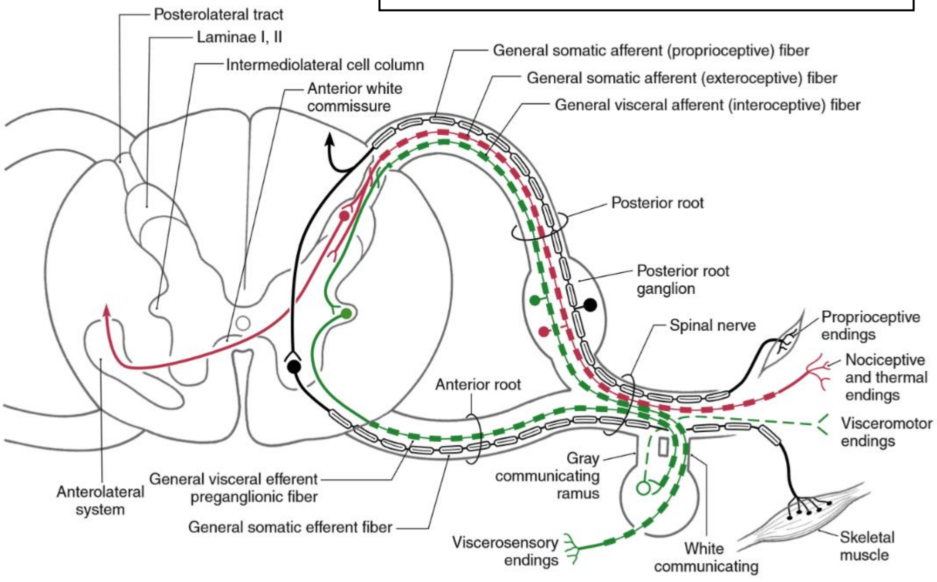
- Anterior median fissure – deepest groove on cord. House the anterior spinal artery.
- Ventrolateral sulcus – exit point of the ventral root.

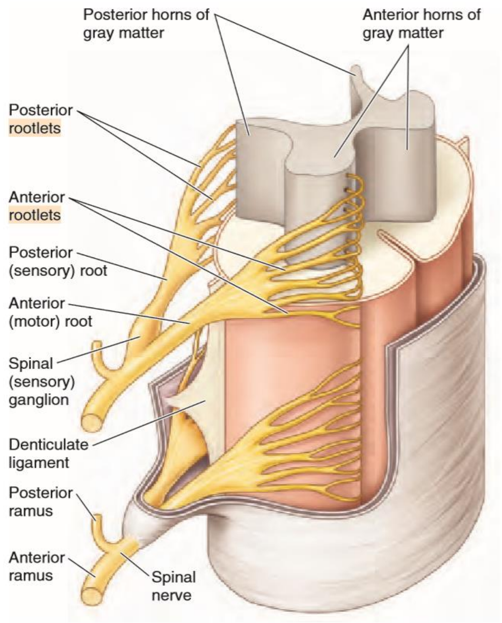

Posterior root (C1)
Obex
Cervical segments [1–8] = cervical part
Posterior root (C8)
Posterior root (T1)
Spinal dura mater
Thoracic segments [1–12] = thoracic part
Posterolateral sulcus
'osterior median sulcus
Posterior funiculus
Posterior root (T12)
Lumbar segments [1–5] = lumbar part
Posterior root (L1)
Cauda equina
Posterior roots (L1–5, S1–5)
Spinal sensory ganglia (S1–5)
Filum terminale, dural part
a
Pons
Medulla oblongata
Hypoglossal nerve [XII]
Accessory nerve [XI]
Decussation of pyramids
Anterior median fissure
Anterolateral sulcus
Cervical enlargement
Spinal dura mater
Lateral funiculus
Anterior funiculus
Lumbosacral enlargement
Conus medullaris
Filum terminale
Filum terminale, dural part
b

The spinal nerve: page 128.

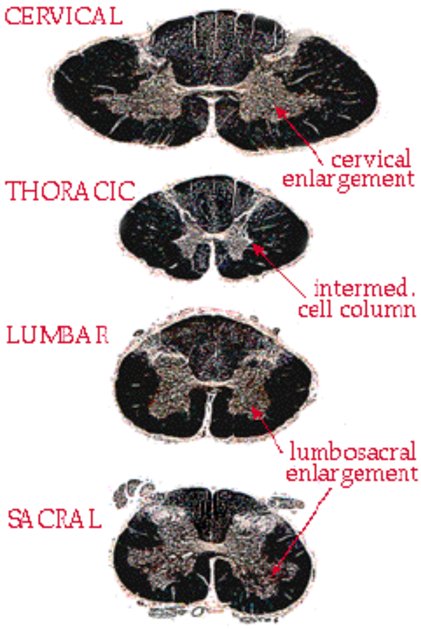
- 31 pairs of spinal nerves: 8 cervical, 12 thoracic, 5 Lumbar, 5 sacral, 1 coccygeal.
- Each spinal nerve has afferent and efferent fibers, coming from 2 diffrent roots:
  - Anterior root, gives the efferent (motor) fibers. These fibers send information from CNS to effector cell. Their cell bodies are found in the anterior horn of spinal gray matter.
  - Posterior root, gives the afferent (sensory) fibers carry information from the PNS to CNS. Their cell bodies are found in the dorsal root ganglion.
- Spinal nerve is formed by posterior and anterior roots, that are collection of anterior / posterior rootlets exciting from the spinal cord.
- The roots unite at the intervertebral foramen to form the spinal nerve. Then the spinal nerve divides to anterior and posterior rami that innervate different structures.
- Functionally: afferent and efferent functions have somatic (concious) and visceral (autonomic, unconcious) components. So in total there are 4 types of fibers – GSA, GVA, GSE, GVE (General Somatic/Visceral Afferent/Efferent). GVE get to preganglionic autonomic ganglia.
  Special fibers (SSE, SVA) involve the cranial nerves and not the spinal cord.
- Dermatome – area of skin that is supplied by one spinal nerve.

**notice that fibers of each kind of sense have different position in the posterior root – medial to lateral


Posterolateral tract
Laminae I, II
Intermediolateral cell column
Anterior white commissure
General somatic afferent (proprioceptive) fiber
General somatic afferent (exteroceptive) fiber
General visceral afferent (interoceptive) fiber
Posterior root
Posterior root ganglion
Spinal nerve
Proprioceptive endings
Nociceptive and thermal endings
Visceromotor endings
Anterior root
Gray communicating ramus
Skeletal muscle
White communicating
Viscerosensory endings
Anterolateral system
General visceral efferent preganglionic fiber
General somatic efferent fiber


Posterior horns of gray matter
Anterior horns of gray matter
Posterior rootlets
Anterior rootlets
Posterior (sensory) root
Anterior (motor) root
Spinal (sensory) ganglion
Denticulate ligament
Posterior ramus
Anterior ramus
Spinal nerve

Cross section of the spinal cord:



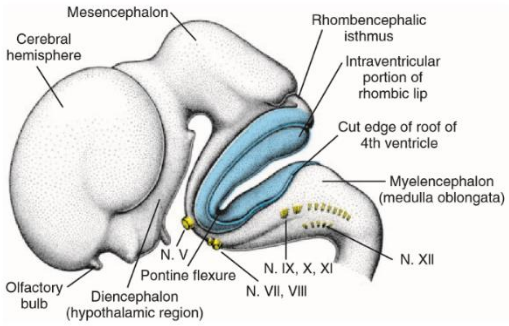
- The first thing to notice is overall shape.
  The Cervical sections tend to be oval (wide and squashed), and. the Lumbar section is round.

- The second thing to check is a ventral horn enlargement.
  At segments that control a limb, the motor neurons are large and numerous. This causes enlarged ventral horns in two places: the lower cervical sections (C5-C8) and the lumbar/sacral sections. If you see an enlargement, you just need to differentiate cervical from lumbar (shape).

- The amount of white matter relative to grey matter decreases as you move down the cord. This is logical – in the white matter of the cervical cord you have all of the axons going to or from the entire body. In sacral cord the white matter contains only the fibers that go to inferior parts of the body. This is why sacral cord looks like it has so much grey matter – really it has just lost all of the white matter.

- Summary, of cues for each level:
  - Cervical – wide flat cord, lots of white matter, ventral horn enlargements.
  - Toracic – has lateral cell column. Also called intermediate horn.
    These are pointed tips between the small dorsal and ventral horns. From it the smpathetic nerves are distribiuted to the body. It is found only in T1-L2/3.
  - Lumbar – Round cord, ventral horn enlargements.
  - Sacral – Small round cord, almost no white matter.

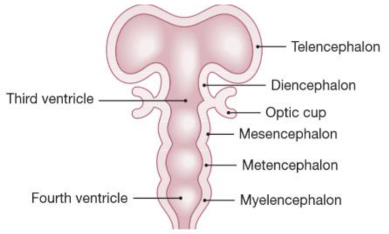
Topic 2 – Parts and surface anatomy of the brain stem

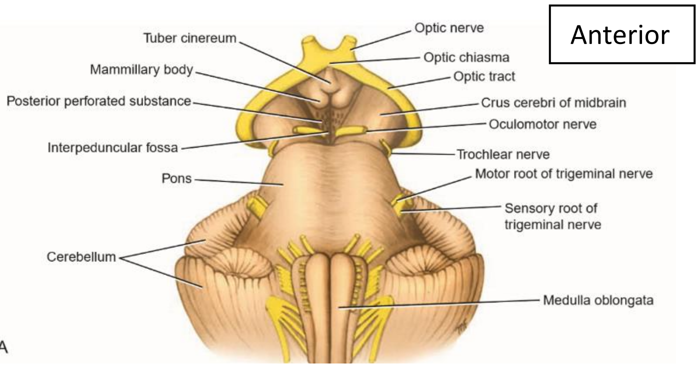

Mesencephalon
Cerebral hemisphere
Rhombencephalic isthmus
Intraventricular portion of rhombic lip
Cut edge of roof of 4th ventricle
Myelencephalon (medulla oblongata)
N. XII
N. IX, X, XI
N. VII, VIII
N. V
Pontine flexure
Diencephalon (hypothalamic region)
Olfactory bulb

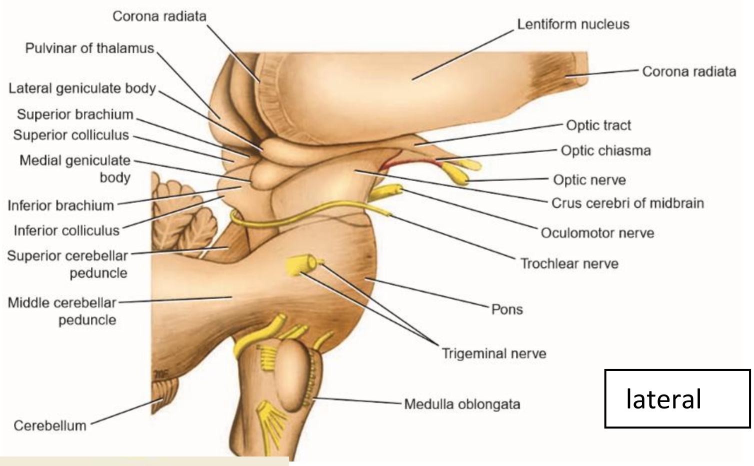
- The Brain stem is found between diencephalon and spinal cord (bordered at foramen magnum level). It includes 3 parts:
  1. Midbrain – also called mesencephalon, from which it develops.
  2. Pons – develop from the metencephalon of rhomb-encephalon.
  3. Medulla oblongata – develop from Myelencephalon part of the rhomb-encephalon.

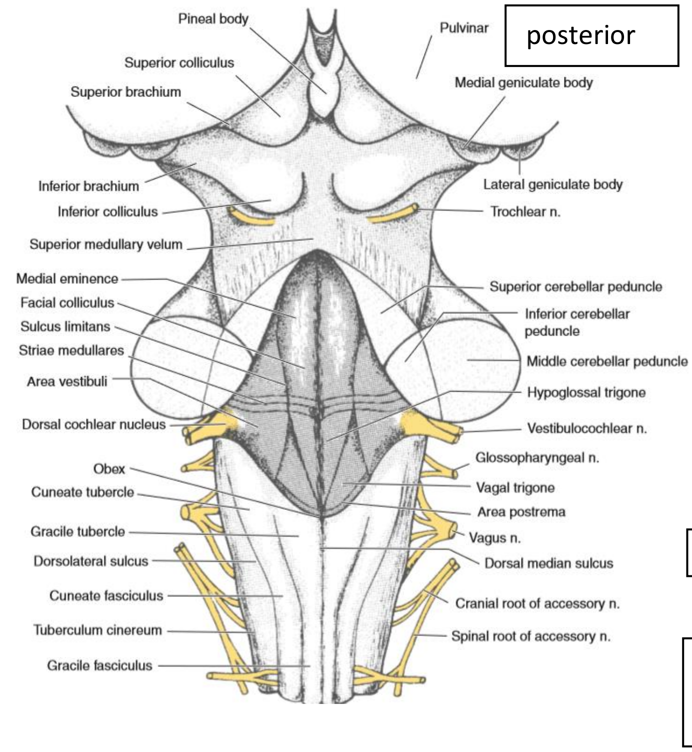
Borders between the parts:

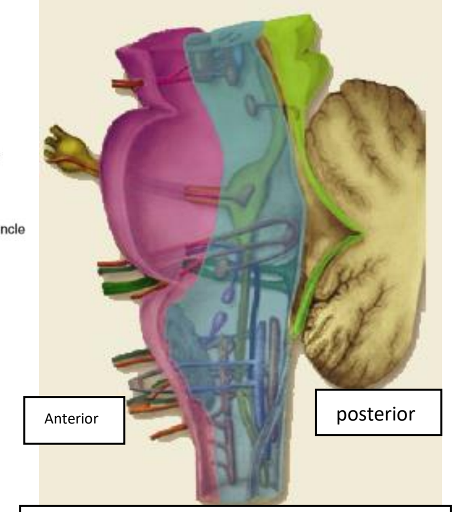
- Pons and midbrain – pons-midbrain junction, made by line between exit of C.N. 4 posteriorly, to rostral edge of the basilar pons.
- Pons and Medulla:
  - Ventral – Ponto-medullary junction = inferior Bulbo-pontine sulcus.
  - Dorsal – Striae Medullares of rhomboid fossa.


Telencephalon
Diencephalon
Third ventricle
Optic cup
Mesencephalon
Metencephalon
Fourth ventricle
Myelencephalon

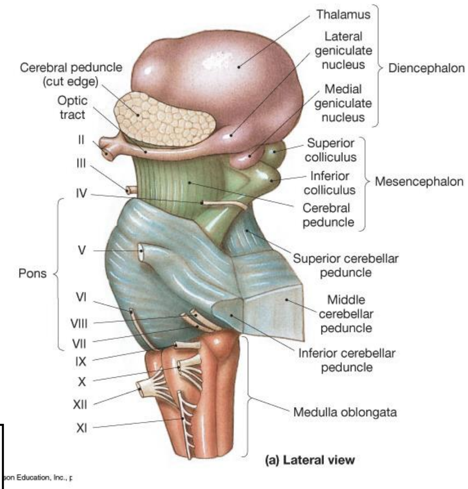

Anterior
Tuber cinereum
Optic nerve
Optic chiasma
Mammillary body
Optic tract
Posterior perforated substance
Crus cerebri of midbrain
Oculomotor nerve
Interpeduncular fossa
Trochlear nerve
Pons
Motor root of trigeminal nerve
Sensory root of trigeminal nerve
Cerebellum
Medulla oblongata
A


Corona radiata
Lentiform nucleus
Pulvinar of thalamus
Corona radiata
Lateral geniculate body
Superior brachium
Optic tract
Superior colliculus
Optic chiasma
Medial geniculate body
Optic nerve
Inferior brachium
Crus cerebri of midbrain
Inferior colliculus
Oculomotor nerve
Superior cerebellar peduncle
Trochlear nerve
Middle cerebellar peduncle
Pons
Trigeminal nerve
Medulla oblongata
Cerebellum
lateral


Pineal body
Pulvinar
posterior
Superior colliculus
Medial geniculate body
Superior brachium
Inferior brachium
Lateral geniculate body
Inferior colliculus
Trochlear n.
Superior medullary velum
Medial eminence
Superior cerebellar peduncle
Facial colliculus
Inferior cerebellar peduncle
Sulcus limitans
Striae medullares
Middle cerebellar peduncle
Area vestibuli
Hypoglossal trigone
Dorsal cochlear nucleus
Vestibulocochlear n.
Glossopharyngeal n.
Obex
Vagal trigone
Cuneate tubercle
Area postrema
Gracile tubercle
Vagus n.
Dorsolateral sulcus
Dorsal median sulcus
Cuneate fasciculus
Cranial root of accessory n.
Tuberculum cinereum
Spinal root of accessory n.
Gracile fasciculus


Anterior
posterior

The inside of the brain-stem is divided into 3 parts, from anterior to posterior – Basis, tegmentum, Tectum (only in midbrain).


Thalamus
Lateral geniculate nucleus
Diencephalon
Medial geniculate nucleus
Cerebral peduncle (cut edge)
Optic tract
II
III
IV
Superior colliculus
Inferior colliculus
Mesencephalon
Cerebral peduncle
Pons
V
VI
VIII
VII
IX
X
XII
XI
Superior cerebellar peduncle
Middle cerebellar peduncle
Inferior cerebellar peduncle
Medulla oblongata
(a) Lateral view
on Education, Inc.,

Mesencephalon (midbrain) – 1.5 cm.

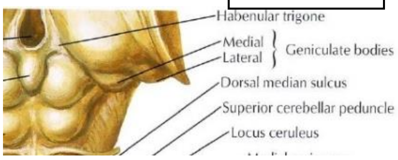
- Location: between the diencephalon and the pons.
  Superior border: posterior commissure and mammillary body, separate it from diencephalon.
  inferior border: frenulum of the superior medullary velum.
- Has 3 parts: tectum (posterior, the colliculi, only in the midbrain), tegmentum (middle) and basis (anterior – the cerebral peduncles).
- contains the cerebral aqueduct, which interconnects the 3rd and 4th ventricles.
- Supplied by superior cerebellar artery and posterior cerebral artery, branches of basilar artery.

1. ventral surface:
   a) 2 cerebral peduncles – also called crus cerebri. Superiorly they enter the cerebral hemispheres, and inferiorly to the basilar pons.
   b) interpeduncular fossa – between the 2 cerebral peduncles. It contains:
      1) oculomotor nerve (CN III) exit through that fossa, between the superior cerebellar and posterior cerebral arteries.
      2) posterior perforated substance – Found in that fossa, created by branches of the posterior cerebral and posterior Ccommunicating arteries penetrating enter the brain.
      3) interpeduncular cistern – Sub-arachnoid space of the interpeduncular fossa. Basilar artery passes through it.
      4) The mammillary bodies are found anterior to the interpeduncular fossa.

2. Dorsal surface:
   a) Corpora Quadrigemina – all 4 colliculi together. They form the tectum.
      i. superior colliculus (SC) – Part of visual system. The Pineal gland rests above and between them.
      ii. brachium of the SC – connect SC to the lateral geniculate body of thalamus.
      iii. inferior colliculus (IC) – part of the auditory system.
      iv. brachium of the IC – connect IC to the medial geniculate body of thalamus.
   b) trochlear nerve (C.N. IV) – only C.N. to exit the from dorsal side of brainstem. It exits at the border of the midbrain and pons, below the inferior colliculi.
   c) Quadrigeminal cistern – subarachnoid space posterior to the colliculi.
   d) Superior cerebellar peduncle – exit from this region.

Lemniscal trigone = trigone of lateral lemniscus. Small area below the inferior colliculus. Inner to it passes the lateral lemniscus

Lateral + Medial geniculate bodies

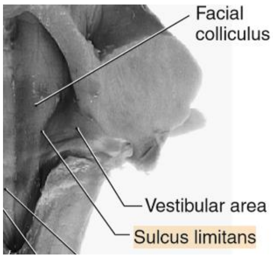


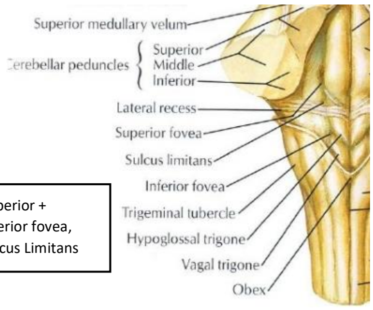
Pons – "bridge" in Latin. Found between cerebral hemispheres. 2.5 cm.

- Location: between the midbrain and the medulla. Include the rostral part of 4th ventricle.
- extends from the superior pontine sulcus (Ponto-Mesencephalic junction) to the inferior pontine sulcus (Ponto-Medullary junction).
- Has 2 parts – tegmentum (posterior), basis (anterior).
- Blood supply – pontine branches of basilar artery – many small branches on the anterior surface (basis) of pons.

1. Ventral surface:
   a) base of the pons – anterior part of pons.
   b) Basilar sulcus – shallow groove, houses the basilar artery.
   c) cranial nerves –
      i. Trigeminal nerve (CN V) – from the middle of pons, little laterally. Marks transition between pons and middle cerebellar peduncle. Has large sensory and small motor roots.
      ii. Abducent (CN IV) – from Ponto-Medullary junction, most medially.
      iii. Facial (CN VII) – from Ponto-Medullary junction.
      iv. Vestibulocochlear nerve (CN VIII) – from Ponto-Medullary junction, most laterally.

2. Dorsal surface: from medial to lateral. All structures are on the floor of the rhomboid fossa (part of pontine tegmentum), covered by the superior medullary vellum:
   a) Median sulcus.
   b) Medial eminence – bulges on the sides of median sulcus.
   c) facial colliculus – inferior to medial eminence. contains the abducent nucleus and internal genu of the facial nerve – fibers of motor nucleus of facial nerve that turn around the abducent nucleus.
   d) Sulcus Limitans – separates the alar plate from the basal plate. Between the fascial colliculus and the vestibular area.
   e) Locus Ceruleus – bluish area. contains the largest collection of norepinephringergic neurons in the CNS. lateral to Sulcus Limitans. Respond to stress.
   f) Striae Medullares of the rhomboid fossa – also called Striae Acustica. horizontal line that divides the rhomboid fossa into superior (pontine) part and inferior (medullary) part.
   g) Vestibular area – partly in pons. overlay the vestibular nuclei.
   h) 3 cerebellar peduncle found on its sides. Fibers from basal pons get to cerebellum through the middle peduncle.
   i) Superior fovea – lateral to facial colliculus.





Superior + inferior fovea, Sulcus Limitans

Medulla oblongata – 3 cm.

- Location: between the pons and the spinal cord. Include the caudal part of 4th ventricle.
- extends from pons-medullary junction (=inferior pontine sulcus, bulbopontine sulcus) to the first cervical nerve (C1) – junction of medulla and spinal cord, at the level of foramen magnum.
- Supplied by branches of the vertebral artery.

1. Ventral surface:
   a) anterior median fissure.
   b) Pyramid– 2 ridges on the sides of the median fissure. contain the corticospinal tract, that pass from pons to motor pyramidal decussation, where it crosses the midline.
   c) Olive – also called inferior olivary eminence. ridges on the side of each pyramid. contains the inferior olivary nucleus. Lateral to it is the inferior cerebellar peduncle (ICP) – connect medulla and cerebellum.
   d) 2 sulci are present, one on each side of the olive. the 4 cranial nerves of the medulla exit Through these sulci.:
      1. Lateral paraolivary sulcus – also called Postolivary sulcus, posterior lateral sulcus. On the lateral side of medulla. 3 cranial nerves arise from it:
         a. Glossopharyngeal nerve (CN IX) most superior.
         b. Vagus nerve (CN X).
         c. Accessory nerve (CN XI) most inferior. Cranial part. (actually according to Hain's CN XI doesn't exit from medulla, but the spinal cord. These branches belong to the vagus).
      2. Medial paraolivary suclus – also called preolivary sulcus, and anterior lateral fissure. Found anteriorly.
         1 cranial nerve arise from it: Hypoglossal nerve (CN-XII).
   e) Abducent nerve (CN VI) exit through the pons-medullary sulcus, at the line of hypoglossal nerve.
   f) CN 7 and 8 exit postero-laterally at the pons-medullary sulcus. CN 7 is more medial and it has 2 roots – motor root, and PNS root (intermediate root), which is more lateral.
   g) Inferior cerebebrllar peduncle – on the side.

2. Dorsal surface: – has 2 parts: open – at the level of 4th ventricle. closed – below the 4th ventricle.

a) Rhomboid fossa – few structures are found at its floor, covered by the inferior vellum (superior to inferior):
   1. Striae Medullares of the rhomboid fossa – horizontal lines. also called striae acustica.
   2. Vestibular trigone – at the superior lateral corner. Overlays the vestibular nuclei.
   3. Inferior fovea – small depression in the limiting sulcus below the striae medullares. lateral to the hypoglossal and vagal trigones.
   4. Calamus scriptorius – consists of the hypoglossal trigone and vagal trigone. the vagal trigone is also called ala cinerea. It is lower and more lateral relative to hypoglossal trigone. Each covers its nucleus.
   5. Sulcus Limitans – separates the alar plate from the basal plate.
   6. Area Postrema (vomiting center – it is circumventricular organ = has loose Blood brain barrier that allows it to sense substances in the blood).

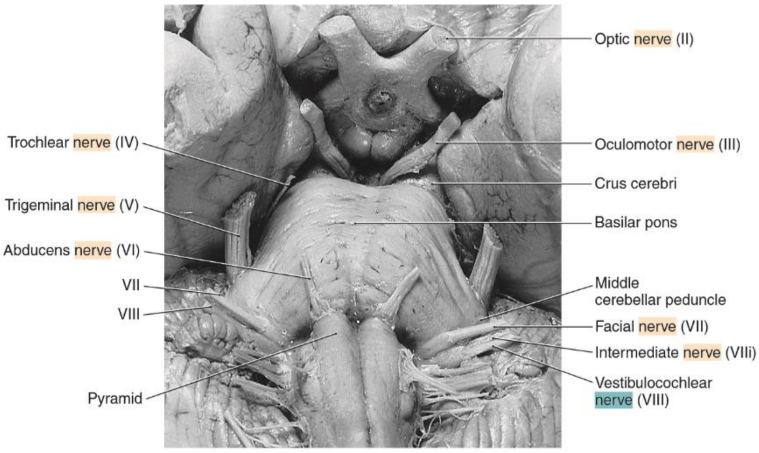
b) Obex – the end of the inferior vellum.

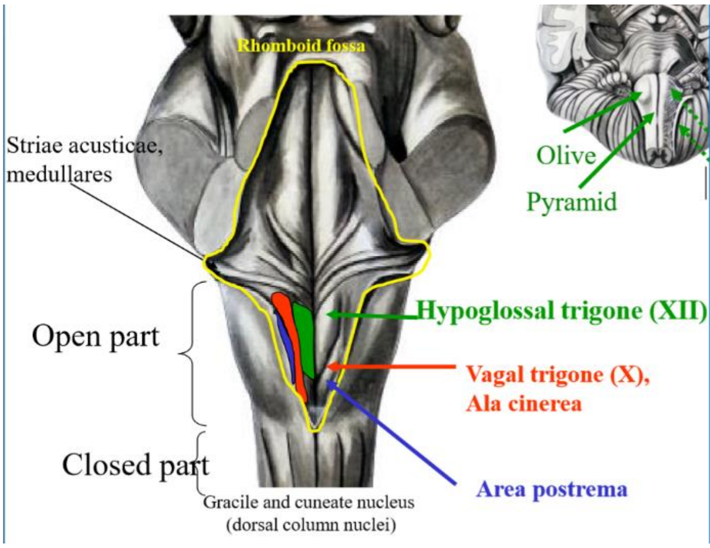
c) Tenia of 4th ventricle – on the roof.

d) Gracile tubercle – contains the gracile nucleus, in spinal cord become Gracile Fasciculus (of Goll’s).

e) Cuneate tubercle – contains the Cuneate nucleus, in spinal cord become Cuneate Fasciculus (of Burdach’s). lateral to the gracile tubercle.

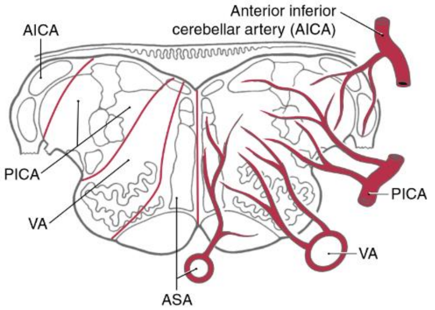
f) Trigeminal tubercle (Tuberculum Cinereum) – laterally to Cuneate tubercle, below the Restiform Body (part of ICP). It is a raised area between the rootlets of the accessory nerve and posterolateral sulcus. It overlies the spinal tract of trigeminal nerve.


Optic nerve (II)
Trochlear nerve (IV)
Oculomotor nerve (III)
Crus cerebri
Trigeminal nerve (V)
Basilar pons
Abducens nerve (VI)
VII
Middle cerebellar peduncle
VIII
Facial nerve (VII)
Intermediate nerve (VIIi)
Pyramid
Vestibulocochlear nerve (VIII)


Rhomboid fossa
Striae acusticae, medullares
Olive
Pyramid
Open part
Hypoglossal trigone (XII)
Vagal trigone (X), Ala cinerea
Closed part
Area postrema
Gracile and cuneate nucleus (dorsal column nuclei)

- Supplied by Vertebral artery system – posterior inferior cerebellar and vertebral artery and its branches (also AICA and anterior spinal artery).

- In the brain stem there are gray and white mater:
  Gray – nuclei of cranial nerve and other nuclei.
  White – fibers of ascending and descending tracts from spine, cerebellum and cortex.


AICA
Anterior inferior cerebellar artery (AICA)
PICA
VA
ASA
PICA
VA

Topic 3 – Borders of the Fourth Ventricle, Rhomboid Fossa

Hain's 86, Barr's 85.

- The 4th ventricle is the ventricular component of the pons and medulla.
- Location: between the cerebellum to the pons and medulla.
- Connections:
  Superiorly – connects to the cerebral aqueduct in the mid brain.
  Inferiorly – connects to the central canal in the spinal cord.
  laterally – has 2 openings, 1 on each side – foramen of Luschka. Also called lateral aperture. Connect the 4th ventricle to the part of subarachnoid space called the cistern of great cerebral vein. Lateral recess – The area in the ventricle adjacent to the foramen of Luschka.
  Posteriorly – 1 opening – foramen of Magendie. Also called median aperture.
  Connect the 4th ventricle to the part of the subarachnoid space called cisterna magna.
- As all ventricular spaces, the 4th ventricle has ependymal cell layer.

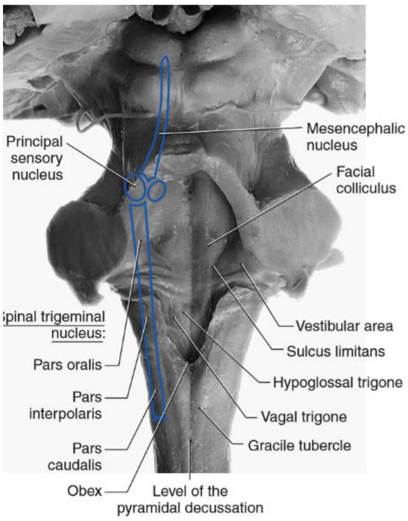
Borders of the 4th ventricle:

- Lateral: superior and inferior cerebellar peduncles.
- Roof (posterior):
  - superior half – superior medullary vellum.
  - inferior half – inferior medullary vellum, and choroid plexus connect it at the inferior part.
  - include the foramina of Magendie and Luschka.
- Floor (anterior): rhomboid fossa.

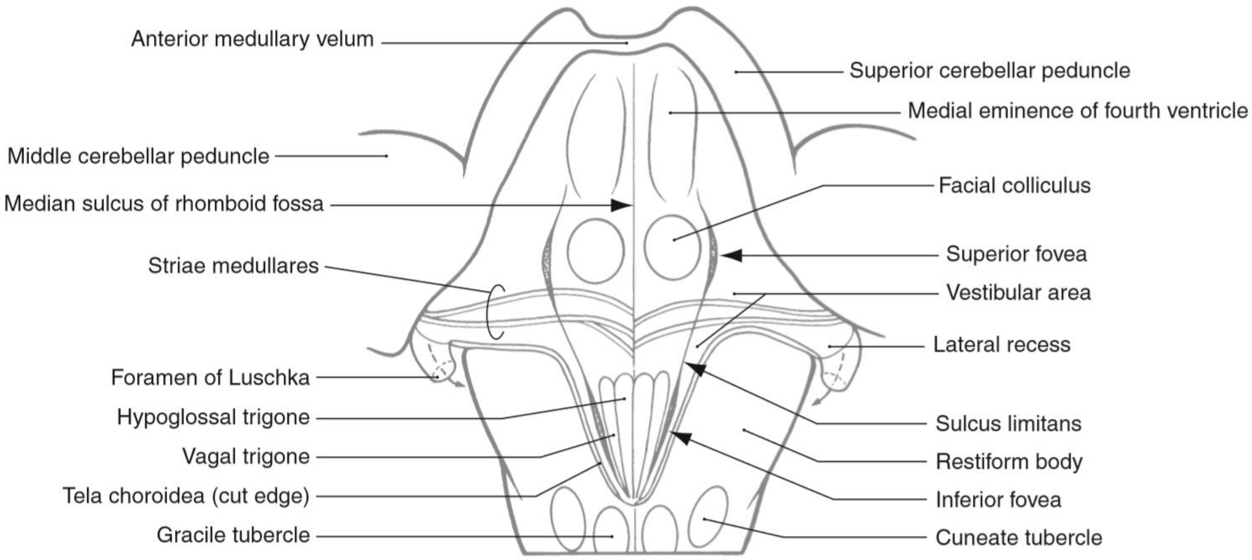
Rhomboid fossa:

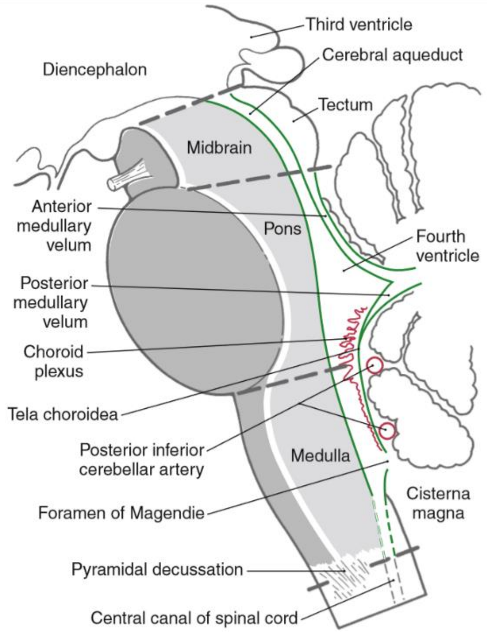
- The floor of the 4th ventricle. anterior in anatomical position.
- It has diamond shape. Formed by tegmentum (back) of pons (superior half) and medulla (inferior half). Both parts are separated by the Striae Medullares of rhomboid fossa.
- Structures at superior part (pons):

  a) Median sulcus.
  b) Medial eminence – bulges on the sides of median sulcus.
  c) facial colliculus – inferior to medial eminence. contains the abducent nucleus and internal genu of the facial nerve – fibers of motor nucleus of facial nerve that turn around the abducent nucleus.
  d) sulcus Limitans – separates the alar plate from the basal plate.
  e) Locus Ceruleus – bluish area. contains the largest collection of norepinephringergic neurons in the CNS. lateral to Sulcus Limitans.
  f) Striae Medullares of the rhomboid fossa – also called Striae Acustic. horizontal lines that divide the rhomboid fossa into the superior pontine portion and the inferior medullary portion.
  g) Vestibular region – partly in pons. overlay the vestibular nuclei.
  h) Superior fovea – lateral to facial colliculus.


Principal sensory nucleus
Mesencephalic nucleus
Facial colliculus
Spinal trigeminal nucleus:
Pars oralis
Pars interpolaris
Pars caudalis
Obex
Level of the pyramidal decussation
Vestibular area
Sulcus limitans
Hypoglossal trigone
Vagal trigone
Gracile tubercle

- Structure of inferior part (Open medulla):
  a) Striae Medullares of the rhomboid fossa – horizontal lines. also called Striae Acustic.
  b) Inferior fovea – small depression in the limiting sulcus below the Striae Medullares. lateral to the hypoglossal and vagal trigones.
  c) Calamus scriptorius – consists of the hypoglossal trigone and vagal trigone (more lateral and inferior). Each covers its nucleus.
  d) Sulcus Limitans – both in medulla and pons.
  e) Area Postrema (vomiting center) – it is a circumventricular organ. Has loose blood brain barrier that enables it to identify substances in the blood.
  f) Obex – inferior angle.


Anterior medullary velum
Superior cerebellar peduncle
Medial eminence of fourth ventricle
Middle cerebellar peduncle
Median sulcus of rhomboid fossa
Facial colliculus
Superior fovea
Striae medullares
Vestibular area
Lateral recess
Foramen of Luschka
Hypoglossal trigone
Sulcus limitans
Restiform body
Vagal trigone
Tela choroidea (cut edge)
Inferior fovea
Gracile tubercle
Cuneate tubercle


Third ventricle
Cerebral aqueduct
Diencephalon
Tectum
Midbrain
Anterior medullary velum
Pons
Fourth ventricle
Posterior medullary velum
Choroid plexus
Tela choroidea
Posterior inferior cerebellar artery
Medulla
Cisterna magna
Foramen of Magendie
Pyramidal decussation
Central canal of spinal cord

Roof of 4th ventricle:

- The roof is made by few structures.
- Openings: at the middle of the roof – foramen of Magendie.
  At the lateral part of roof – foramen of Luschka.
- Borders:
  - Superior part:
    1. Superior cerebellar peduncle.
    2. Superior medullary vellum between the peduncles.
  - Inferior part: inferior medullary vellum. From its inferior part – the choroid plexus of the 4th ventricle is suspended. Part of it extends out of the ventricle through the foramen of Luschka. this extension through the foramen of Luschka is called the "Bochdale bunch of flowers", it is barely seen. Might be seen on the cerebellum.
  - Fastigium: top of the roof, At the angle between the superior and inferior part. Protrudes into the cerebellum.
  - Lateral: inferior cerebellar peduncles.

** Intro and pictures for topics 4-6

Hain's 181. This part is just for better understanding the idea of cranial nerve nuclei.

- The surface anatomy of the brainstem is described in topic 2.

Classification of the cranial nerves:

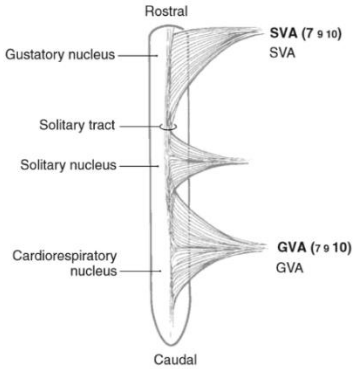
1. General / Special. Special are the things that relate to taste and smell.
2. Voluntary and conscious (Somatic) vs. involuntary and un conscious (Visceral).
3. Motor (Efferent) or sensory (Afferent).

- General Somatic efferent (GSE): voluntary functions of eyes and tongue: C.N. 3, 4, 6, 12.
- Special Somatic efferent (SSE): motor function of food and air intake: C.N. 5, 7, 9, 10, 11.
- Special visceral efferent (SVE): motor function of food intake: C.N. 9, 10.
- General Visceral efferent (GVE): parasympathetic motor function of eyes (C.N. 3) glands (C.N. 9, 10) and internal organs as cardiac muscle lung and GI (C.N. 10). Pass through ganglia.
- General Somatic afferent (GSA): sensation and proprioception from head. C.N. 5, 9, 10.
- Special Visceral afferent (SVA): sensation from taste buds: C.N. 7, 9, 10.
- General Visceral afferent (GVA): input from internal organ (unconscious): C.N. 9, 10.

The following nuclei function with more than 1 nerve:

Sensory nuclei –

- Solitary nucleus:
  Location: medulla. All fibers first enter the solitary tract, and then end in the solitary nucleus.
  Function: receives all visceral afferent information from all cranial nerves.
  superior part – receive taste information (Special VA) – gustatory nucleus.
  inferior part – receive visceral sensation – sometimes called cardiorespiratory nucleus.
  - gustatory nucleus: located on the superior part of solitary nucleus.
    Function: receive taste sensation from C.N. 7, 9, 10.
- Trigeminal sensory nuclei: divided to 3, of them only the spinal is associated with few cranial nerves.
  - Spinal trigeminal nucleus: somatic sensory receiving center of the brainstem – thermal information, crud touch and pain (nociception).
    Receive sensation from the face, head and neck, through cranial nerves 5, 7, 9, 10.
    fibers enter through spinal trigeminal tract.



Motor nuclei –

- Nucleus Ambiguus: (SVE) column of motor neurons situated dorsal to the inferior olivary nucleus. Delivered by C.N. 9, 10, 11.
  Supply: striated muscles of the soft palate, pharynx, and larynx (except tensor veli palatine, by C.N. 5), together with striated muscle fibers in the upper part of the esophagus.
- Salivatory nuclei:
  Location: consists of groups of neurons located lateral and medial to the facial motor nucleus.
  Function: (GVE) Give parasympathetic fibers to C.N. 7 and 9, to produce saliva.
  according to Hain's it is divided to superior and Inferior Salivatory nuclei:
  - Superior Salivatory nucleus: gives parasympathetic fibers to the facial nerve. Its axons exit the brain stem as the intermediate nerve, and then join the facial nerve.

**lacrimal nucleus can be considered as part of it, that supplies the lacrimal gland.

its fibers supply:

1. lacrimal gland, and nasal and palate mucous glands through the pterygopalatine ganglion. Through the greater petrosal nerve and pterygopalatine ganglion.
2. Sublingual and submandibular glands, Through the chorda tympani and submandibular ganglion.

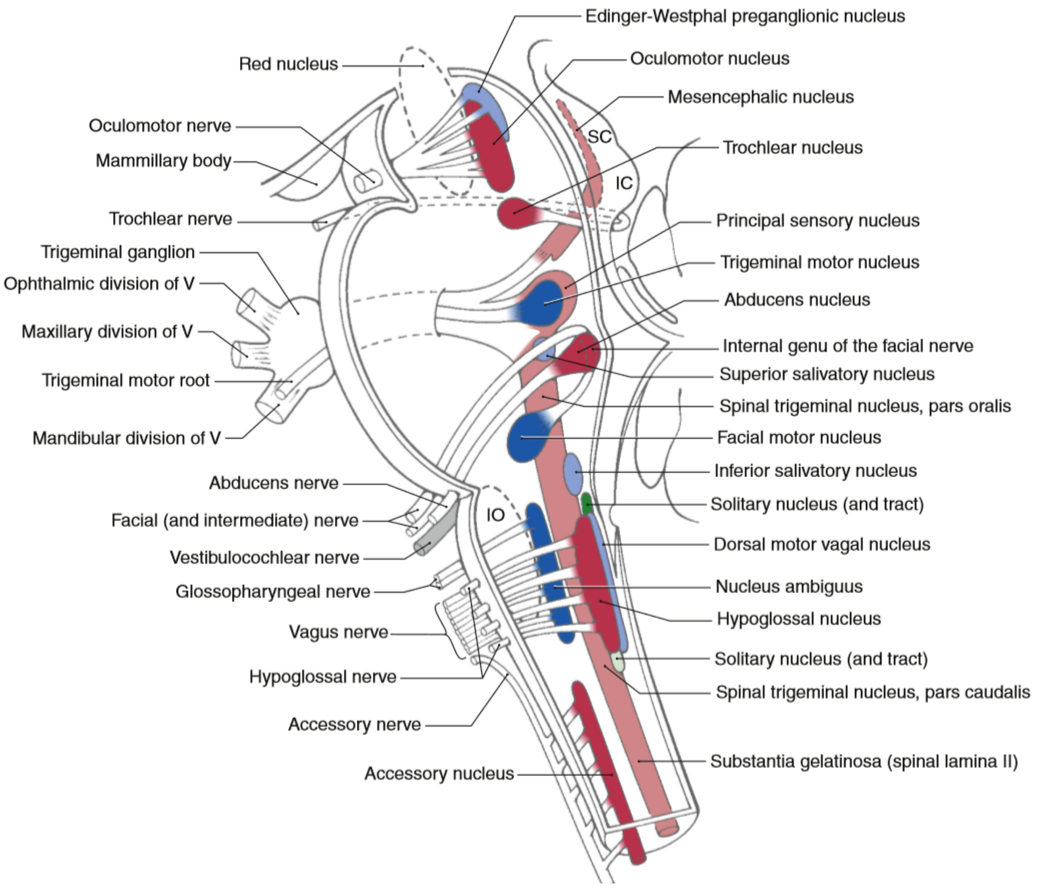
- Inferior Salivatory nucleus: innervates the parotid gland, through C.N. 9 > tympanic nerve > lesser petrosal nerve > otic ganglion > auriculotemporal > parotid gland.

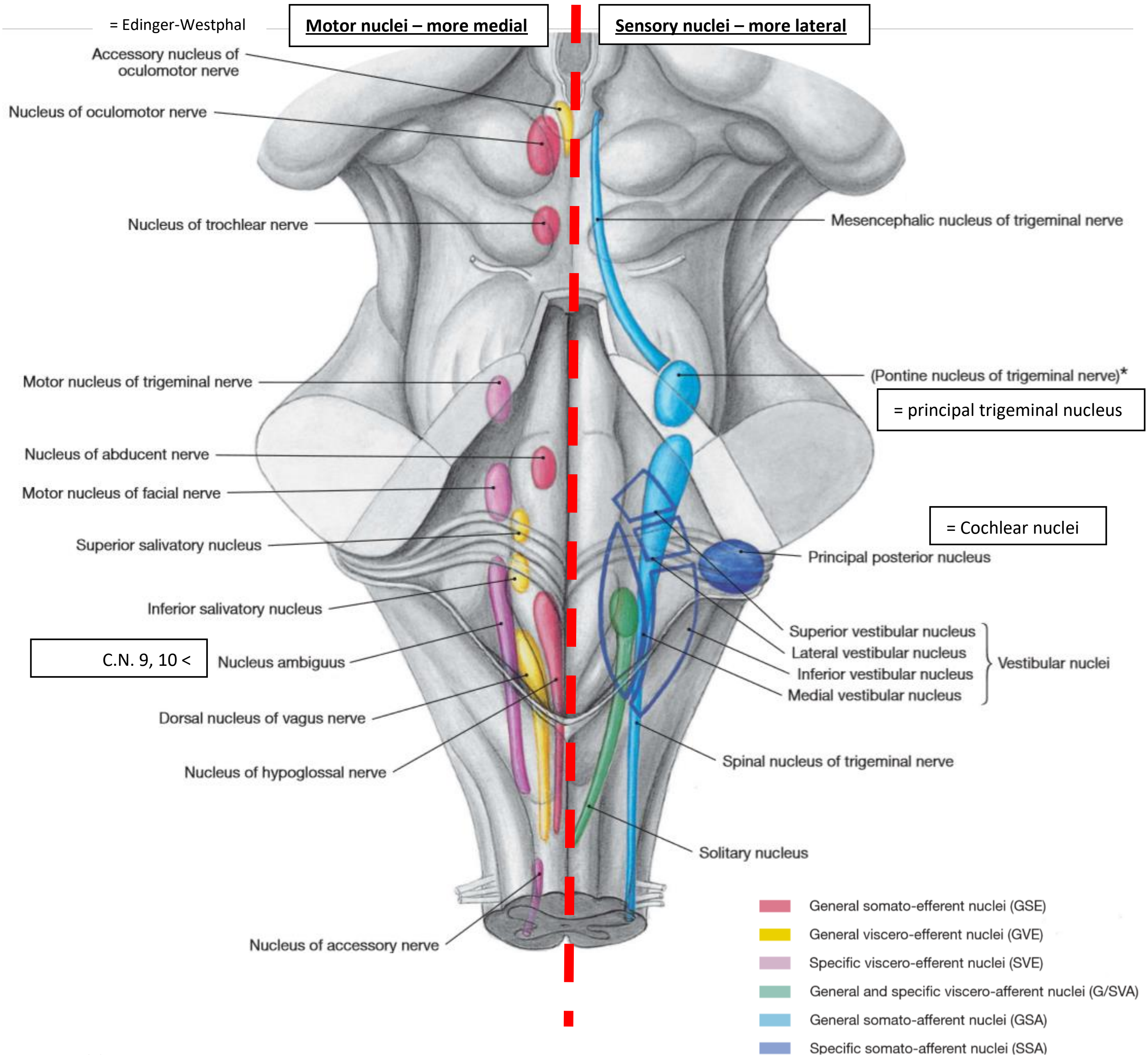
- Arrangement of sensory nuclei:
  in the lateral aspect of brainstem. From medial to lateral:
  Solitary nucleus, vestibular nuclei, trigeminal nuclei, cochlear nuclei.

  Arrangement of the Vestibular and cochlear nuclei:

  Location: medial and inferior vestibular nuclei in the medulla, anterior and posterior cochlear nuclei in the pons-medulla junction, superior and lateral vestibular nuclei in the pons.

  Function: receive information of hearing, balance and equilibrium from middle ear, through C.N. 8.
- Arrangement of motor nuclei: 3 columns, from medial to lateral –
  1. motor nuclei of C.N. 3, 4, 6, 12 are next to the midline, and all innervate skeletal muscles (SE).
  2. motor nuclei of the PNS (GVE): dorsal motor vagal nucleus, inferior and Superior Salivatory nucleus, Edinger-Westphal nucleus (C.N.3). all terminate in peripheral ganglia.
  3. Nucleus Ambiguus, facial motor nucleus, trigeminal motor nucleus. (SVE) form discontinuous column.


Edinger-Westphal preganglionic nucleus
Red nucleus
Oculomotor nucleus
Mesencephalic nucleus
Oculomotor nerve
Mammillary body
SC
Trochlear nucleus
IC
Trochlear nerve
Principal sensory nucleus
Trigeminal ganglion
Trigeminal motor nucleus
Ophthalmic division of V
Abducens nucleus
Maxillary division of V
Internal genu of the facial nerve
Superior salivatory nucleus
Trigeminal motor root
Spinal trigeminal nucleus, pars oralis
Mandibular division of V
Facial motor nucleus
Inferior salivatory nucleus
Abducens nerve
Solitary nucleus (and tract)
Facial (and intermediate) nerve
IO
Vestibulocochlear nerve
Dorsal motor vagal nucleus
Glossopharyngeal nerve
Nucleus ambiguus
Vagus nerve
Hypoglossal nucleus
Solitary nucleus (and tract)
Hypoglossal nerve
Spinal trigeminal nucleus, pars caudalis
Accessory nerve
Substantia gelatinosa (spinal lamina II)
Accessory nucleus

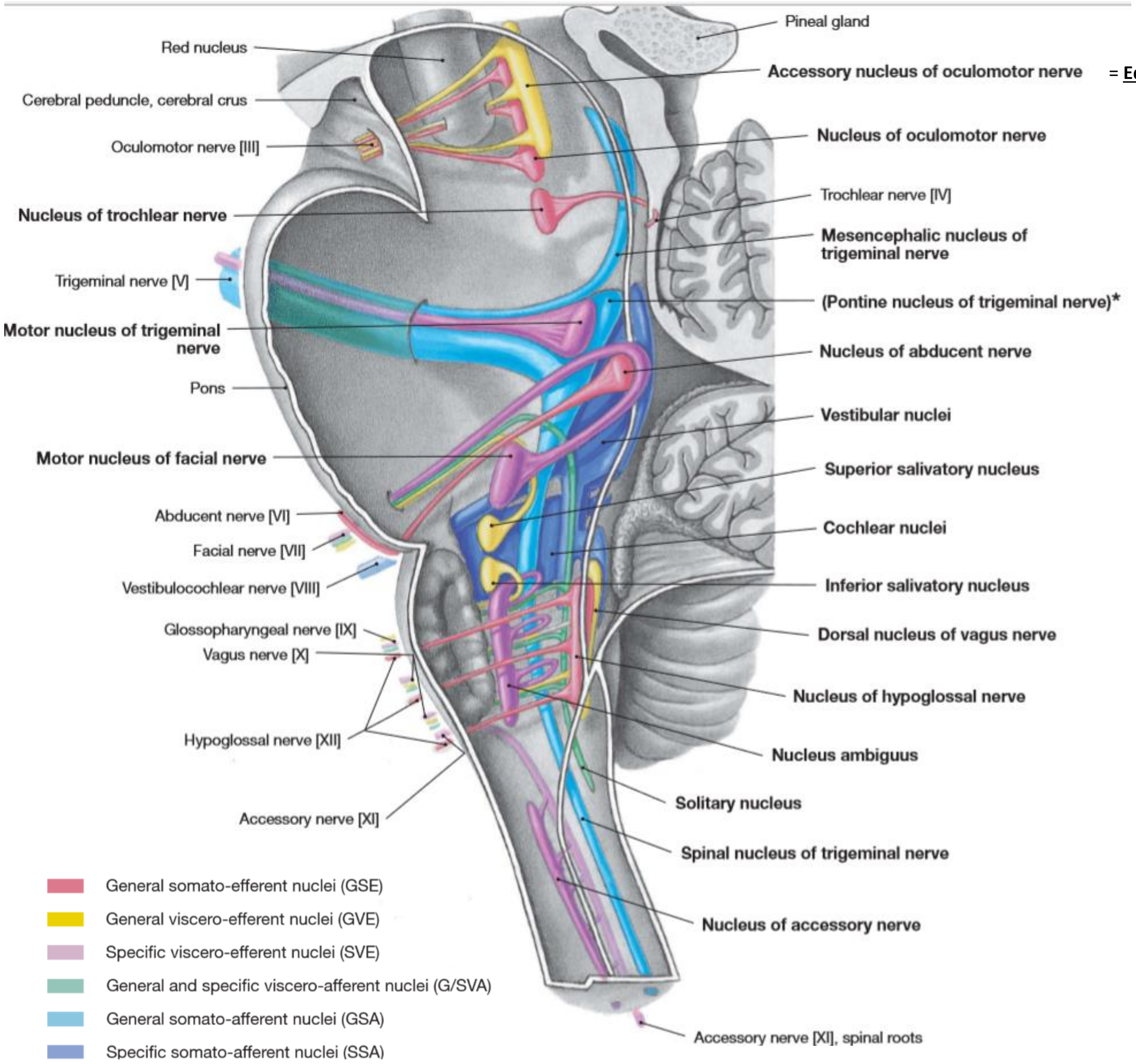

= Edinger-Westphal
Motor nuclei – more medial
Sensory nuclei – more lateral
Accessory nucleus of oculomotor nerve
Nucleus of oculomotor nerve
Nucleus of trochlear nerve
Mesencephalic nucleus of trigeminal nerve
Motor nucleus of trigeminal nerve
(Pontine nucleus of trigeminal nerve)*
= principal trigeminal nucleus
Nucleus of abducent nerve
Motor nucleus of facial nerve
Superior salivatory nucleus
= Cochlear nuclei
Principal posterior nucleus
Inferior salivatory nucleus
Superior vestibular nucleus
Lateral vestibular nucleus
Inferior vestibular nucleus
Medial vestibular nucleus
Vestibular nuclei
C.N. 9, 10 <
Nucleus ambiguus
Dorsal nucleus of vagus nerve
Spinal nucleus of trigeminal nerve
Nucleus of hypoglossal nerve
Solitary nucleus
Nucleus of accessory nerve
General somato-efferent nuclei (GSE)
General viscero-efferent nuclei (GVE)
Specific viscero-efferent nuclei (SVE)
General and specific viscero-afferent nuclei (G/SVA)
General somato-afferent nuclei (GSA)
Specific somato-afferent nuclei (SSA)

**Motor nuclei originate from the basal plate.

**Sensory nuclei originate from the alar plate.

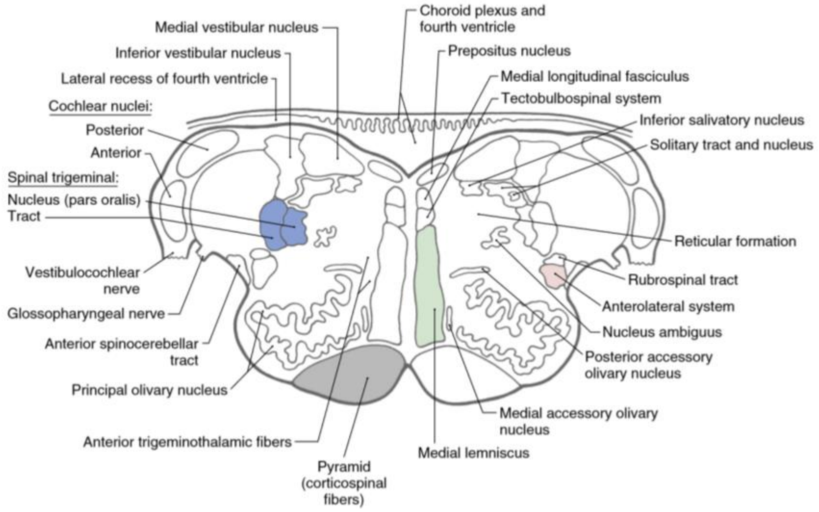
According to lecture – we have 2 somatomotor nuclei columns – nuclei that are one above the other, as seen on the left side of the picture:
dorsomedial column: cranial nerves 3,4,6,12. General Somatic efferent.
ventrolateral column: cranial nerves 5,7,9,10,11. Special Visceral efferent.

The other nuclei are visceromotor: 3, 7, 9, 10. General visceral efferent, between the 2 others.


Red nucleus
Cerebral peduncle, cerebral crus
Oculomotor nerve [III]
Nucleus of trochlear nerve
Trigeminal nerve [V]
Motor nucleus of trigeminal nerve
Pons
Motor nucleus of facial nerve
Abducent nerve [VI]
Facial nerve [VII]
Vestibulocochlear nerve [VIII]
Glossopharyngeal nerve [IX]
Vagus nerve [X]
Hypoglossal nerve [XII]
Accessory nerve [XI]
Pineal gland
Accessory nucleus of oculomotor nerve
Nucleus of oculomotor nerve
Trochlear nerve [IV]
Mesencephalic nucleus of trigeminal nerve
(Pontine nucleus of trigeminal nerve)*
Nucleus of abducent nerve
Vestibular nuclei
Superior salivatory nucleus
Cochlear nuclei
Inferior salivatory nucleus
Dorsal nucleus of vagus nerve
Nucleus of hypoglossal nerve
Nucleus ambiguus
Solitary nucleus
Spinal nucleus of trigeminal nerve
Nucleus of accessory nerve
Accessory nerve [XI], spinal roots
🟥 General somato-efferent nuclei (GSE)
🟨 General viscero-efferent nuclei (GVE)
🟪 Specific viscero-efferent nuclei (SVE)
🟩 General and specific viscero-afferent nuclei (G/SVA)
🟦 General somato-afferent nuclei (GSA)
🟦 Specific somato-afferent nuclei (SSA)

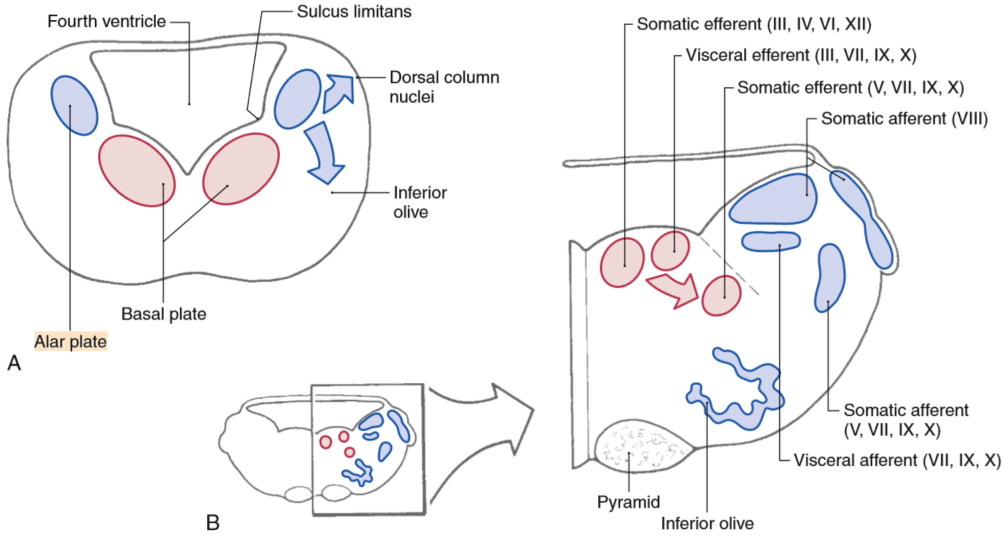
= **Edinger-Westphal**

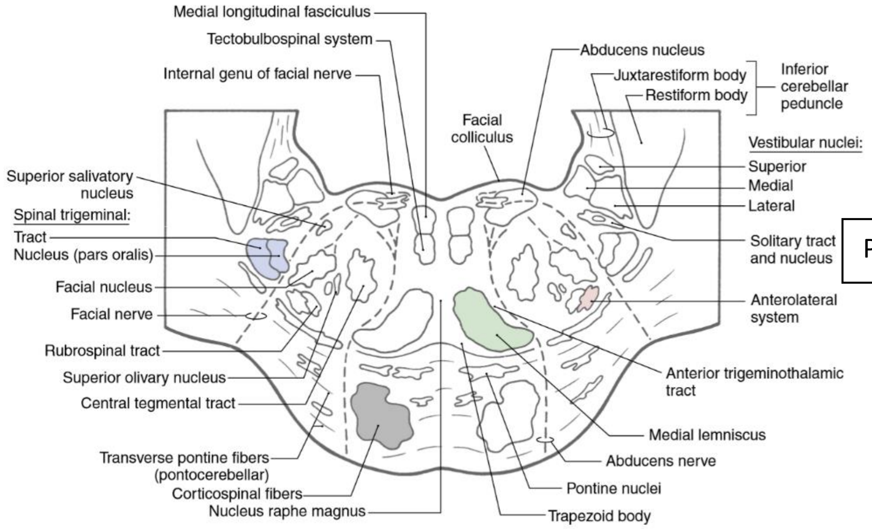
Cross section of brain stem at the level of medulla, pons and midbrain:


Medial vestibular nucleus
Inferior vestibular nucleus
Lateral recess of fourth ventricle
Cochlear nuclei:
Posterior
Anterior
Spinal trigeminal:
Nucleus (pars oralis)
Tract
Vestibulocochlear nerve
Glossopharyngeal nerve
Anterior spinocerebellar tract
Principal olivary nucleus
Anterior trigeminothalamic fibers
Pyramid (corticospinal fibers)
Medial lemniscus
Choroid plexus and fourth ventricle
Prepositus nucleus
Medial longitudinal fasciculus
Tectobulbospinal system
Inferior salivatory nucleus
Solitary tract and nucleus
Reticular formation
Rubrospinal tract
Anterolateral system
Nucleus ambiguus
Posterior accessory olivary nucleus
Medial accessory olivary nucleus

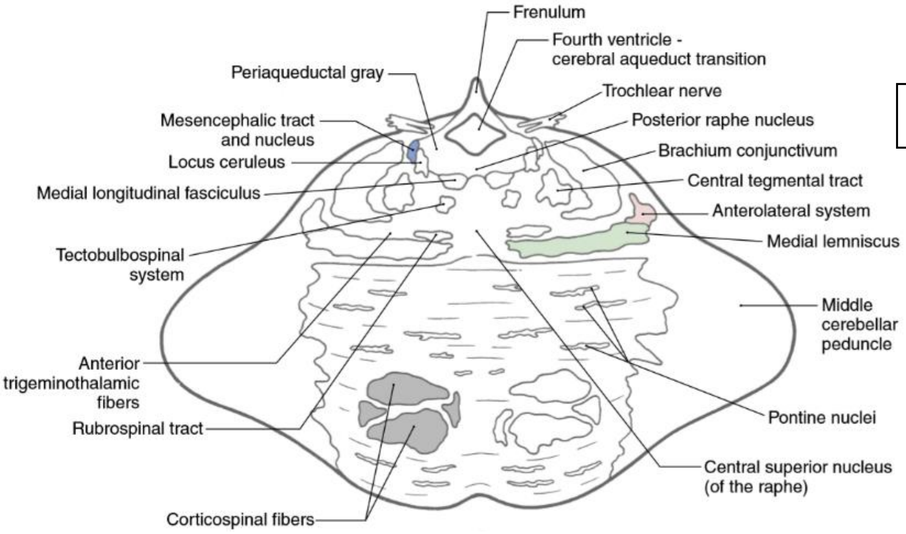
Medulla

- Developmentally, sensory nuclei develop from alar plate, more lateral and posterior (blue).
  the motor nuclei are formed by the basal plate, more medial and anterior (red).
  both are separated by Sulcus Limitans.


Fourth ventricle
Sulcus limitans
Dorsal column nuclei
Inferior olive
Basal plate
Alar plate
A
Somatic efferent (III, IV, VI, XII)
Visceral efferent (III, VII, IX, X)
Somatic efferent (V, VII, IX, X)
Somatic afferent (VIII)
Somatic afferent (V, VII, IX, X)
Visceral afferent (VII, IX, X)
Pyramid
Inferior olive
B


Medial longitudinal fasciculus
Tectobulbospinal system
Internal genu of facial nerve
Facial colliculus
Abducens nucleus
Juxtarestiform body
Restiform body
Inferior cerebellar peduncle
Vestibular nuclei:
Superior
Medial
Lateral
Superior salivatory nucleus
Spinal trigeminal:
Tract
Nucleus (pars oralis)
Facial nucleus
Facial nerve
Rubrospinal tract
Superior olivary nucleus
Central tegmental tract
Transverse pontine fibers (pontocerebellar)
Corticospinal fibers
Nucleus raphe magnus
Solitary tract and nucleus
Anterolateral system
Anterior trigeminothalamic tract
Medial lemniscus
Abducens nerve
Pontine nuclei
Trapezoid body

Pons – Level of facial colliculus


Frenulum
Fourth ventricle - cerebral aqueduct transition
Periaqueductal gray
Trochlear nerve
Mesencephalic tract and nucleus
Posterior raphe nucleus
Locus ceruleus
Brachium conjunctivum
Medial longitudinal fasciculus
Central tegmental tract
Anterolateral system
Medial lemniscus
Tectobulbospinal system
Middle cerebellar peduncle
Anterior trigeminothalamic fibers
Rubrospinal tract
Pontine nuclei
Central superior nucleus (of the raphe)
Corticospinal fibers

midbrain – Level of frenulum

Topic 4 – Parts and surface anatomy of the medulla oblongata. Demonstration of the cranial nerves originating in the medulla oblongata, the projection of their brainstem nuclei, and their corresponding cranial nerve foramina.

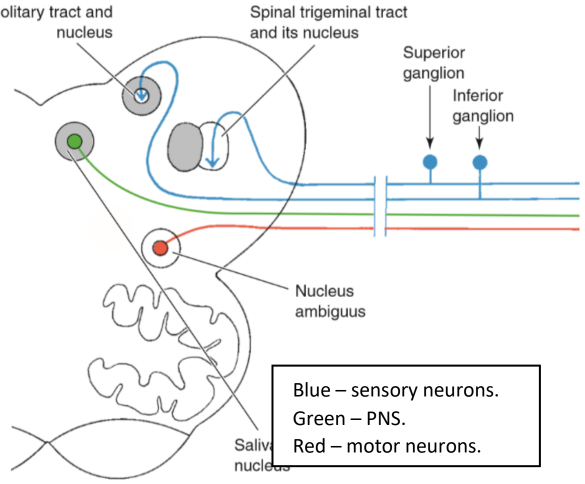
Hain's 183, Barr's 134.

- Surface anatomy is described on topic 2.

Cranial nerves:

- 4 cranial nerves are associated with the Medulla – C.N. 9, 10, 11, 12.

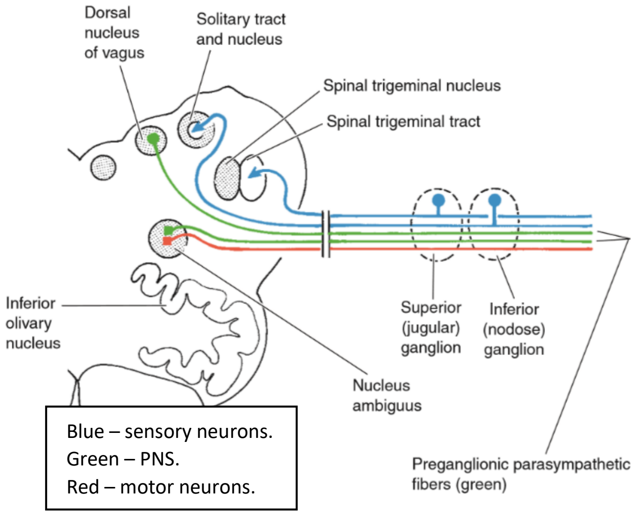
1. C.N. 9 – Glossopharyngeal:
    - Nerve of the third pharyngeal arch.
    - Nerve: exits the medulla at the lateral paraolivary sulcus, above vagus nerve. Leave the skull through the jugular foramen, there the inferior (VA) and superior (SA) glossopharyngeal ganglia are found.


Solitary tract and nucleus
Spinal trigeminal tract and its nucleus
Superior ganglion
Inferior ganglion
Nucleus ambiguus
Saliv
nucle

Blue – sensory neurons.
Green – PNS.
Red – motor neurons.

    - Nuclei:
        - Nucleus Amiguus – SE.
          Location: Medial part of medulla.
          Function: supply the Styloglossal muscle.
          Nerve: through glossopharyngeal nerve.
        - Inferior Salivatory nucleus – VE, parasympathetic.
          Location: lateral and medial to the facial motor nucleus, in medial medulla.
          Function: give parasympathetic innervation to the parotid gland.
          Nerve: axons leave C.N. 9 > join tympanic nerve > become lesser petrosal nerve > synapse in the otic ganglion > through auriculotemporal nerve to parotid gland.
        - Solitary nucleus – GVA.
          Location: lateral medulla.
          Functions:
          1. Chemoreceptors from Carotid body.
          2. Information from Parotid gland and oropharynx.
          Nerve: glossopharyngeal nerve > inferior ganglion of C.N. 9 > fibers enter through jugular foramen > solitary tract > solitary nucleus.
        - Gustatory nucleus – SVA.
          Location: superior part of solitary nucleus, lateral medulla.
          Function: carry taste sensation from the posterior third of the tongue.
        - Spinal trigeminal nucleus – SA.
          Location: lateral medulla.
          Function: receives cutaneous sensation from a small area of the pinna and external auditory canal and posterior third of the tongue.
          Nerve: pass through the superior ganglion.

2. C.N. 10 – Vagus:
   - Nerve of 4th and 6th pharyngeal arches.
   - Nerve: exit through the lateral paraolivary sulcus, below C.N. 9. Leaves the skull through the jugular foramen, immediately after it are the inferior (VA) and superior (SA) vagus ganglia.
   - Ala Cinerea – older name of the vagal trigone, under which lays the vagus motor nucleus.
   - Nuclei:

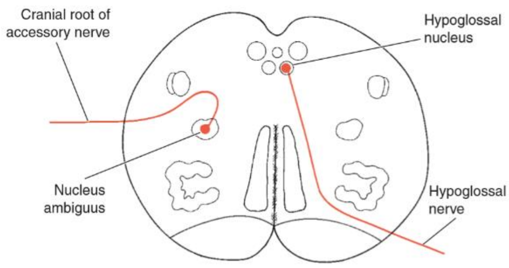

Dorsal nucleus of vagus
Solitary tract and nucleus
Spinal trigeminal nucleus
Spinal trigeminal tract
Inferior olivary nucleus
Superior (jugular) ganglion
Inferior (nodose) ganglion
Nucleus ambiguus
Preganglionic parasympathetic fibers (green)

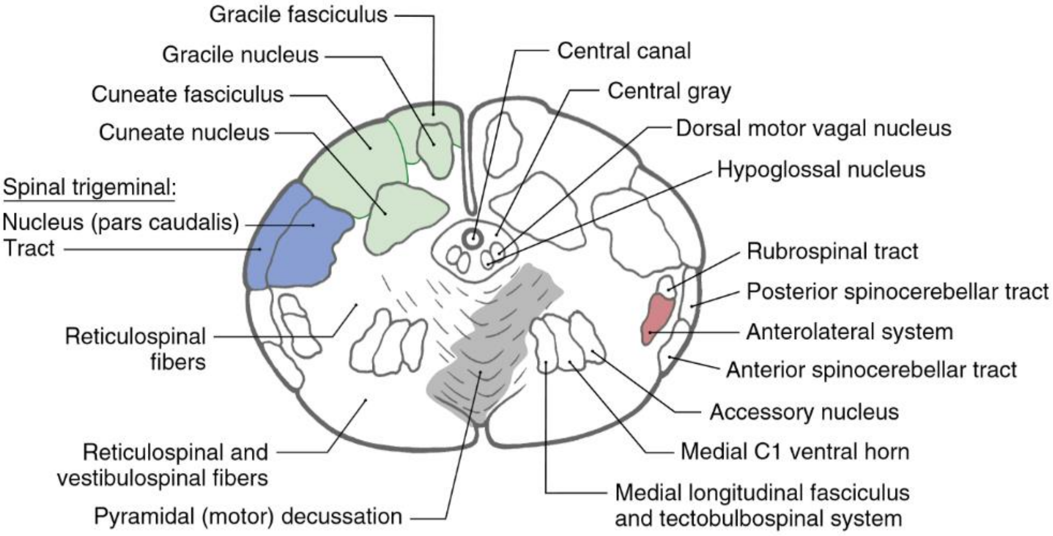
Blue – sensory neurons.
Green – PNS.
Red – motor neurons.

     - Nucleus Ambiguus – SVE.
       Location: medial part of medulla.
       Function: motor. Supply the pharynx constrictor, intrinsic laryngeal muscles (the vocalis), palatine muscles (tensor veli palatine innervated C.N. 5), and skeletal muscle in upper half of esophagus.
     - Dorsal motor nucleus of vagus – VE, parasympathetic.
       Location: medial medulla. Beneath the vagal trigon.
       Function: motor. supply parasympathetic innervation.
       Nerve: through the vagus nerve, end in the intramural (terminal) ganglia, at the wall of supplied organs (lungs, heart, oesophagus and GI down to splenic flexure of colon).
     - Solitary nucleus – GVA.
       Location: lateral medulla, Caudal part of the nucleus (Cardiorespiratory nucleus).
       Function: receive visceral sensation from heart, aortic arch, pharynx and larynx, lungs, and GI down to Splenic flexure.
     - Gustatory nucleus – SVA.
       Location: superior part of solitary nucleus.
       Function: information from taste buds on the epiglottis and base of the tongue.
     - Spinal trigeminal nucleus – GSA.
       Function: pain and thermal sensations from small area on the ear and part of the external auditory meatus and from the dura of the posterior cranial fossa.
       Nerve: cell bodies located in the superior ganglion.

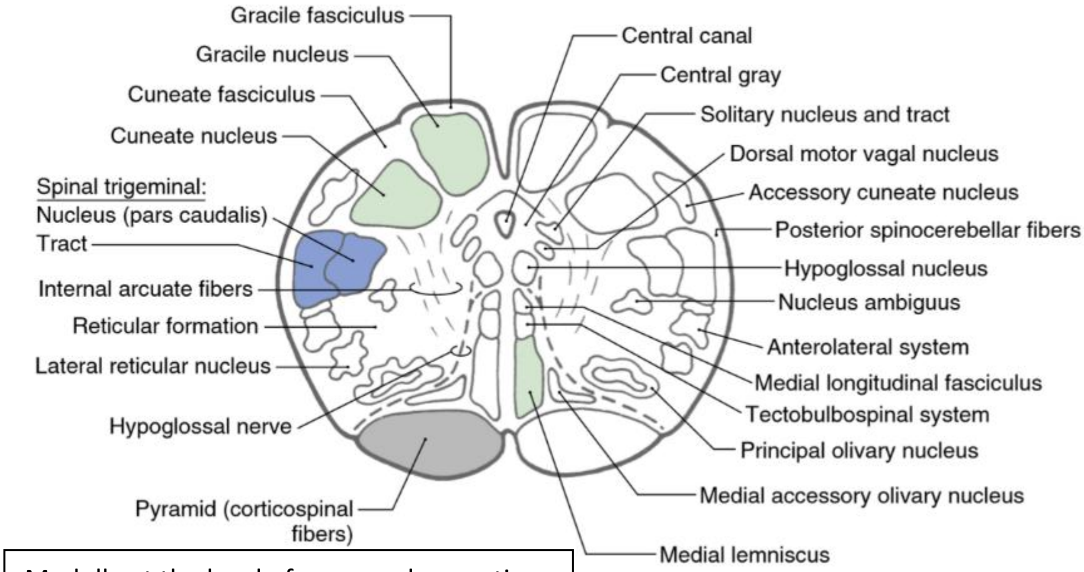
3. C.N. 11 – Accessory nerve: GSE.
   - In the past, described as having cranial and spinal parts. Now it is known as having only cervical part. (*the teachers might still see it as in the past).
   - Function: innervates sternocleidomastoid and trapezius muscles.
   - Nucleus: motor neurons in C1-C5.
   - Nerve: axons exit the lateral aspect of spinal cord, form the nerve, ascend through foramen magnum. After entering the posterior cranial fossa, join vagal fibers from Nucleus Ambiguus. then exit through jugular foramen.
     **this mixing with the vagus was believed to be the cranial part of the nerve.
     The fibers of cranial part exit through the lateral paraolivary nucleus.

4. C.N. 12 – Hypoglossal: SE.
   - Function: innervates intrinsic muscles of tongue – styloglossus, hyoglossus, and genioglossus muscles.
   - Nucleus: hypoglossal nucleus. between dorsal nucleus of vagus and midline of medulla. Beneatha the hypoglossal triangle.
   - Nerve: pass anteriorly in medulla next to medial lemniscus and pyramid. Exit through medial paraolivary nucleus as C.N. 12. Exit skull through hypoglossal canal.


Cranial root of accessory nerve
Hypoglossal nucleus
Nucleus ambiguus
Hypoglossal nerve


Gracile fasciculus
Gracile nucleus
Cuneate fasciculus
Cuneate nucleus
Spinal trigeminal:
Nucleus (pars caudalis)
Tract
Reticulospinal fibers
Reticulospinal and vestibulospinal fibers
Pyramidal (motor) decussation
Central canal
Central gray
Dorsal motor vagal nucleus
Hypoglossal nucleus
Rubrospinal tract
Posterior spinocerebellar tract
Anterolateral system
Anterior spinocerebellar tract
Accessory nucleus
Medial C1 ventral horn
Medial longitudinal fasciculus and tectobulbospinal system

Medulla at the level of motor decussation


Gracile fasciculus
Gracile nucleus
Cuneate fasciculus
Cuneate nucleus
Spinal trigeminal:
Nucleus (pars caudalis)
Tract
Internal arcuate fibers
Reticular formation
Lateral reticular nucleus
Hypoglossal nerve
Pyramid (corticospinal fibers)
Central canal
Central gray
Solitary nucleus and tract
Dorsal motor vagal nucleus
Accessory cuneate nucleus
Posterior spinocerebellar fibers
Hypoglossal nucleus
Nucleus ambiguus
Anterolateral system
Medial longitudinal fasciculus
Tectobulbospinal system
Principal olivary nucleus
Medial accessory olivary nucleus
Medial lemniscus

Medulla at the level of sensory decussation

Topic 5 – Parts and surface anatomy of the pons. Demonstration of the cranial nerves originating in the pons, the projection of their brainstem nuclei, and their corresponding cranial nerve foramina.

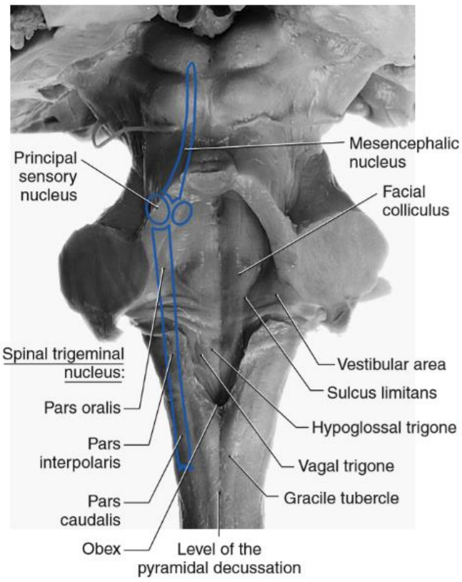
Hain's 188, Barr's 117

- Surface anatomy is described in topic 2.

Cranial nerves:

- 4 cranial nerves are associated with the Pons – C.N. 5, 6, 7, 8.
  C.N. 6, 7, 8 are considered cranial nerve of the pons-medullary junction, from medial to lateral.

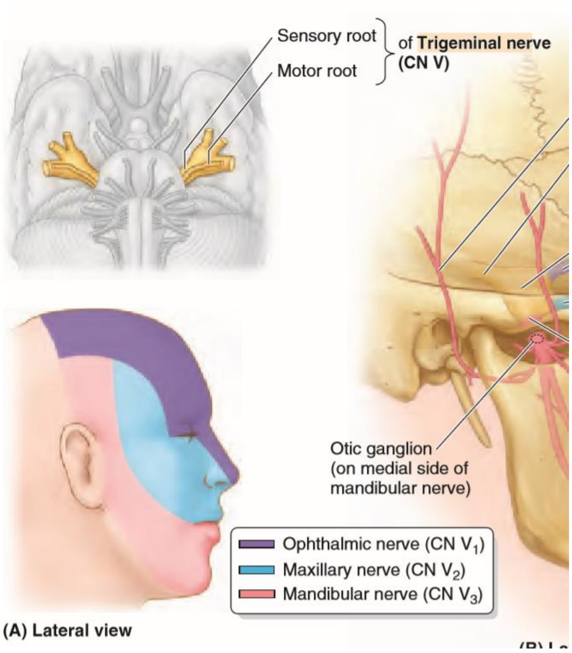
1. C.N. 5 – Trigeminal nerve: SE, SA.
   - Nerve of the 1st pharyngeal arch.
   - Functions:
     1. Receives sensory information – pain, thermal and discriminative sensations, and proprioception – from the following: A. Face – including cornea and conjunctiva. B. head – including nasal mucosa, teeth, tongue. Together with C.N. 7, 9, 10.
     2. Controls mastication muscles and the following muscles: tensor tympani, tensor veli palatine, mylohyoid, anterior digastric.
   - Nuclei: 3 sensory (form a column) and 1 motor.
     The sensory nuclei are located one over the other. From inferior:
     - Spinal trigeminal nucleus – GSA
       Location: lateral medulla and pons, most inferior trigeminal nucleus.
       Function: pain and thermal sensations from the face and head.
       Input: cranial nerves 5, 7, 9, 10.
       Structure: has 3 parts:
         a. Caudal – from C3 level in the spinal cord to obex.
         b. Interpolar – from obex to hypoglossal nucleus.
         c. Oral – to principal nucleus above it.

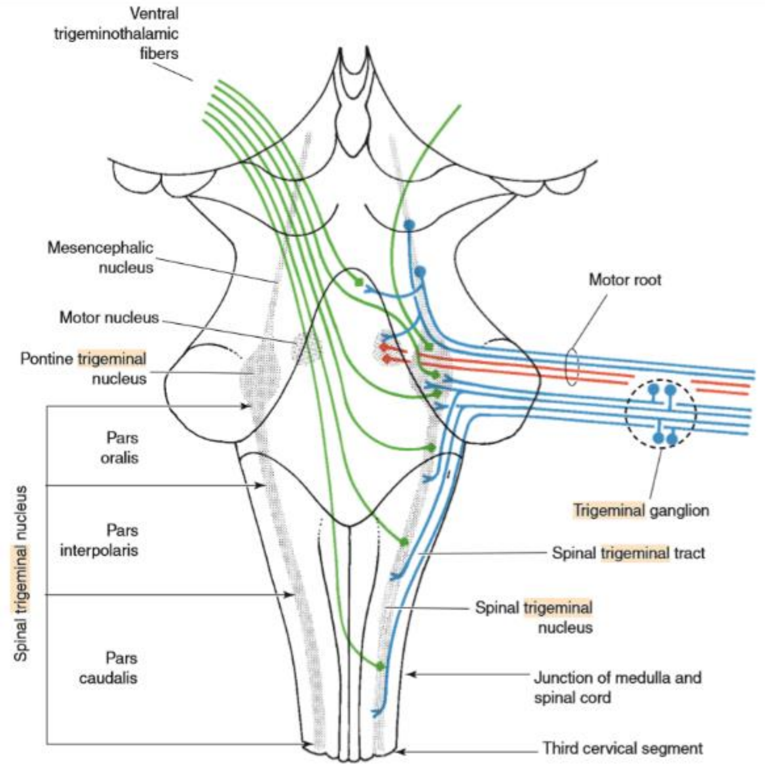

Principal sensory nucleus
Mesencephalic nucleus
Facial colliculus
Spinal trigeminal nucleus:
Pars oralis
Pars interpolaris
Pars caudalis
Obex
Level of the pyramidal decussation
Vestibular area
Sulcus limitans
Hypoglossal trigone
Vagal trigone
Gracile tubercle

     - principal sensory nucleus – GSA
       Location: lateral pons, superior to spinal trigeminal nucleus.
       Function: Sensation of discriminative touch from face and oral cavity.
       ** information from the principal and spinal nuclei go to thalamus (VPM) through the anterior and posterior trigeminothalamic tracts, and ends on the somatosensory cortex.
     - Mesencephalic nucleus – GSA
       Location: lateral midbrain, lateral to the periaqueductal gray. Most superior trigeminal nucleus.
       Function: proprioceptive information, from masticatory muscles, extraocular muscles, and periodontal ligament receptors.
     - Motor nucleus – GSE
       Location: Pons. medial to principal sensory trigeminal nucleus.
       Function: Control mastication muscles and the following muscles: tensor tympani, tensor veli palatine, mylohyoid, anterior digastric.

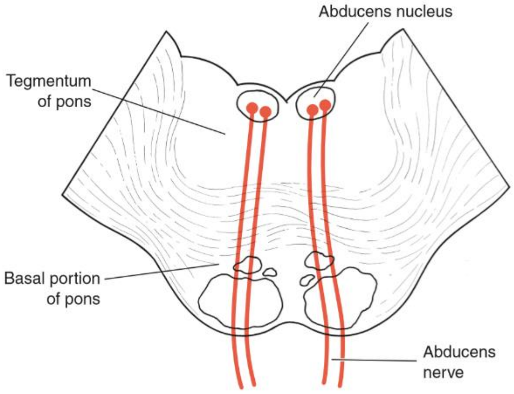
Nerve: exit the skull through foramen ovale, along with the mandibular nerve.

- General summary of the Nerve: exit the lateral pons, as large sensory root that enter the trigeminal ganglion (contains the sensory cell bodies. Found in the trigeminal impression at the tip of the petrous bone) and small motor roots that doesn't join the ganglion.
  The nerve marks the border between the basilar pons and the middle cerebella peduncle.
  It has 3 divisions:
  most sensitive
  V1 – ophthalmic: forehead to superior eyelid. Exit through superior orbital fissure.
  V2 – maxillary: lower eyelid to upper lip, and temporal area. Exit through foramen rotundum, then through inferior orbital fissure.
  V3 – mandibular – lower lip to mandible, and lateral area around the ear. Exit through foramen ovale.


Sensory root
Motor root
of Trigeminal nerve (CN V)
Otic ganglion (on medial side of mandibular nerve)
Ophthalmic nerve (CN V_1)
Maxillary nerve (CN V_2)
Mandibular nerve (CN V_3)
(A) Lateral view

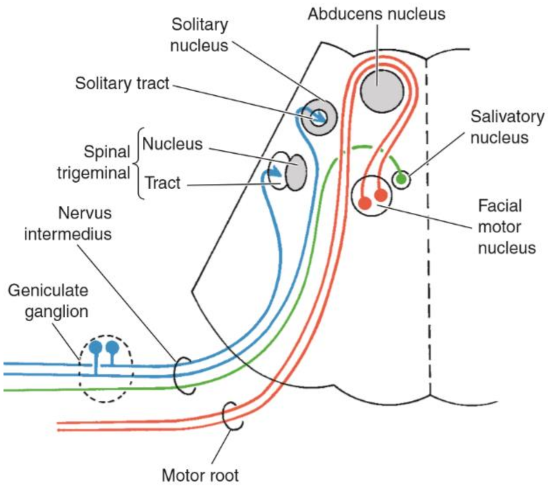

Ventral trigeminothalamic fibers
Mesencephalic nucleus
Motor nucleus
Pontine trigeminal nucleus
Pars oralis
Pars interpolaris
Pars caudalis
Spinal trigeminal nucleus
Motor root
Trigeminal ganglion
Spinal trigeminal tract
Spinal trigeminal nucleus
Junction of medulla and spinal cord
Third cervical segment

2. C.N. 6 – Abducent nerve: GSE.
   - Function: innervate the ipsilateral lateral rectus muscle. Participate in eye reflexes.
   - Nucleus: located internal to facial colliculus, at the floor of rhomboid fossa. Send fibers to the contralateral oculomotor nucleus, through the medial longitudinal fasciculus, for stimulation of medial rectus (so one eye looks laterally, and the other will look medially).
   - Nerve: exit through the Ponto-Medullary junction. Continue through the Prepontine cistern to the Cavernous Sinus, adjacent to internal carotid artery. Enter the orbit thru the Superior Orbital Fissure.


Abducens nucleus
Tegmentum of pons
Basal portion of pons
Abducens nerve

3. C.N. 7 – Facial nerve:
   - Nerve of 2nd pharyngeal arch.

- Functions: SVA (taste), GSE (facial muscles), GVE (saliva), GSA (external ear), SVA (glands and pharynx).
- Nuclei:
  - Facial motor nucleus – GSE.
    Location: superior to pons-medullary junction. Anterior to abducent nucleus.
    Function:
    1. Supply muscles of facial expression, posterior digastric and stylohyoid muscle.
    2. Supply the Stapedius muscle.
    Nerve: go posteromedially, arch around C.N. 6 (make the facial colliculus in the rhomboid fossa), joined by fibers of Superior Salivatory nucleus, and exit separately through the pons. Enter internal acoustic meatus, pass in the facial canal, exit the stylomastoid foramen, enter the parotid gland, and reach muscles of the face.
  - Superior Salivatory nucleus – VE.
    Location: in the medial part of pons.
    Function:
    1. PNS supply to mucous membrane of the hard and soft palates, nasal cavity, lacrimal gland and paranasal sinuses. Join the maxillary nerve.
    2. PNS supply to submandibular and sublingual glands, and part of mucous surface of tongue and oral cavity.
    Nerve: intermediate nerve, that comes from the nucleus, join facial nerve in the pons, separate from it, and join again after exiting the brain stem. Gives 2 branches:
    1. Greater petrosal nerve, is responsible for the first function. It ends in the pterygopalatine ganglion.
    2. Chorda tympani, for the second function. pass across tympanic membrane, exit through the Petrotympanic fissure, join the lingual nerve in the infratemporal fossa, and reach to submandibular ganglion, and anterior 2/3 of tongue (for taste).



  - Gustatory nucleus – SVA.
    Location: superior part of solitary nucleus.
    Function: taste sensation from anterior 2/3 of tongue.
    Nerve: chorda tympani.
  - Cardiorespiratory nucleus – GVA.
    Location: caudal part of solitary nucleus.
    Function: sensations from the sublingual and submandibular salivary glands and mucous membranes of the palate and nasopharynx.
  - Spinal trigeminal nucleus – GSA
    Function: receive cutaneous innervation of small area of the external ear and external auditory canal.
    Nerve: fibers join in the geniculate ganglion, then travel with intermediate nerve.

- General summery of the Nerve: composed of two roots, the facial nerve (SE) and the intermediate nerve (VA, VE, and SA fibers). The 2 join inside the pons, but exit separately.

Then they join again, and Enter internal acoustic meatus.
In the middle ear, the nerve travels in the facial canal. After entering it turns posteriorly and later exit inferiorly through the stylomastoid foramen.

1. Facial nerve – The main nerve, joined by the intermediate nerve and gives all the branches. Exit the brain stem through the cerebellopontine angle.
2. Chorda tympani – pass across the inner surface of the tympanic membrane, exit through the Petrotympanic fissure, join the lingual nerve in the infratemporal fossa, and reach to submandibular ganglion, and anterior 2/3 of tongue.
3. greater petrosal nerve (VE) – branch at the internal genu, from the geniculate ganglion. Leaves through foramen Lacerum, joined by deep petrosal nerve and end in the pterygopalatine ganglion.
4. intermediate nerve – from Superior Salivatory nucleus, carry parasympathetic fibers. Join facial nerve in the pons, separate from it, and join again after exiting the brain stem. Includes fibers of the greater petrosal nerve, that end in the pterygopalatine ganglion (end in the lacrimal gland and nasal + palatal mucous glands), and fibers of the chorda tympani, that end in the submandibular ganglion and supplies the salivary glands.
5. Nerve to stapedius – innervate the stapedius muscle, which is responsible for middle ear reflex – when eating and talking the muscle pulls the stapedius bone, so person doesn't hear himself eat or talk.

4. C.N. 8 – vestibulocochlear nerve: VA.

Vestibular part – VA.

- Function: affect balance, sense of position and equilibrium, coordination of eye movement.
- Nuclei: superior, inferior, medial and lateral Vestibular nuclei.
- Nerve: vestibular ganglion > internal acoustic meatus > Vestibular nuclei.
- Connections: Cerebellum, C.N. 3, 4, 6 (medial longitudinal lemniscus), spinal cord, other brain stem nuclei.

Cochlear part – VA.

- Function: hearing sensation and modulation of hearing (efferent).
- Nuclei: posterior and anterior cochlear nuclei, level of Striae Medullares of rhomboid fossa
- Nerve: spiral ganglion > internal acoustic meatus > cochlear nuclei.

**the 2 nerves combine as they leave the inner ear, form the Vestibulocochlear nerve, that pass through the cerebellopontine angle, and enter the brain stem through the pons-medullary junction.

Arrangement of the nuclei:

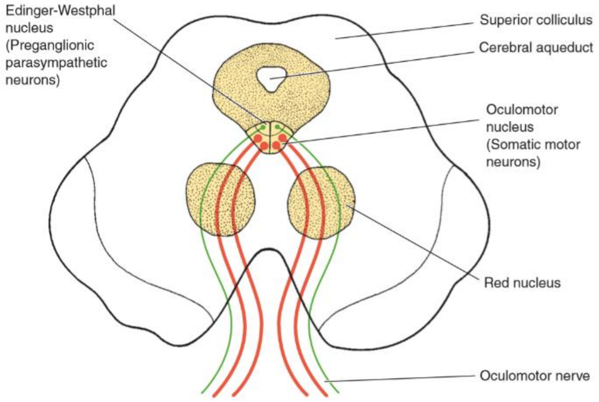
- medial and inferior vestibular nuclei in the medulla, anterior and posterior cochlear nuclei in the pons-medullary junction, superior and lateral vestibular nuclei in the pons.
- They are all sensory nuclei, so they are at the lateral part of brain stem.

Pontine nuclei: (Barr's 84) group of nuclei, involved in motor activity. Found in the anterior part of the pons. Fibers from the cerebral cortex terminate ipsilaterally on neurons that compose the pontine nuclei. Axons from the pontine nuclei cross the midline and constitute to the contralateral middle cerebellar peduncle. The basal pons thus serves as a large synaptic relay station, providing a connection from the cortex of each cerebral hemisphere to the opposite cerebellar hemisphere.

Topic 6 – Parts and surface anatomy of the mesencephalon. Demonstration of the cranial nerves originating in the mesencephalon, the projection of their brainstem nuclei, and their corresponding cranial nerve foramina.

Barr’s 117. Hain's 195.

- Surface anatomy is described on topic 2.


Edinger-Westphal nucleus (Preganglionic parasympathetic neurons)
Superior colliculus
Cerebral aqueduct
Oculomotor nucleus (Somatic motor neurons)
Red nucleus
Oculomotor nerve

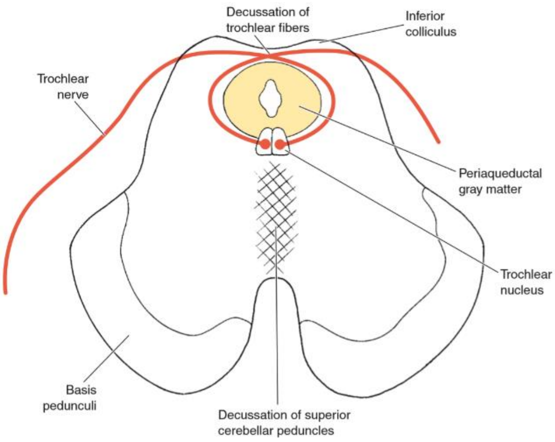
Cranial nerves:

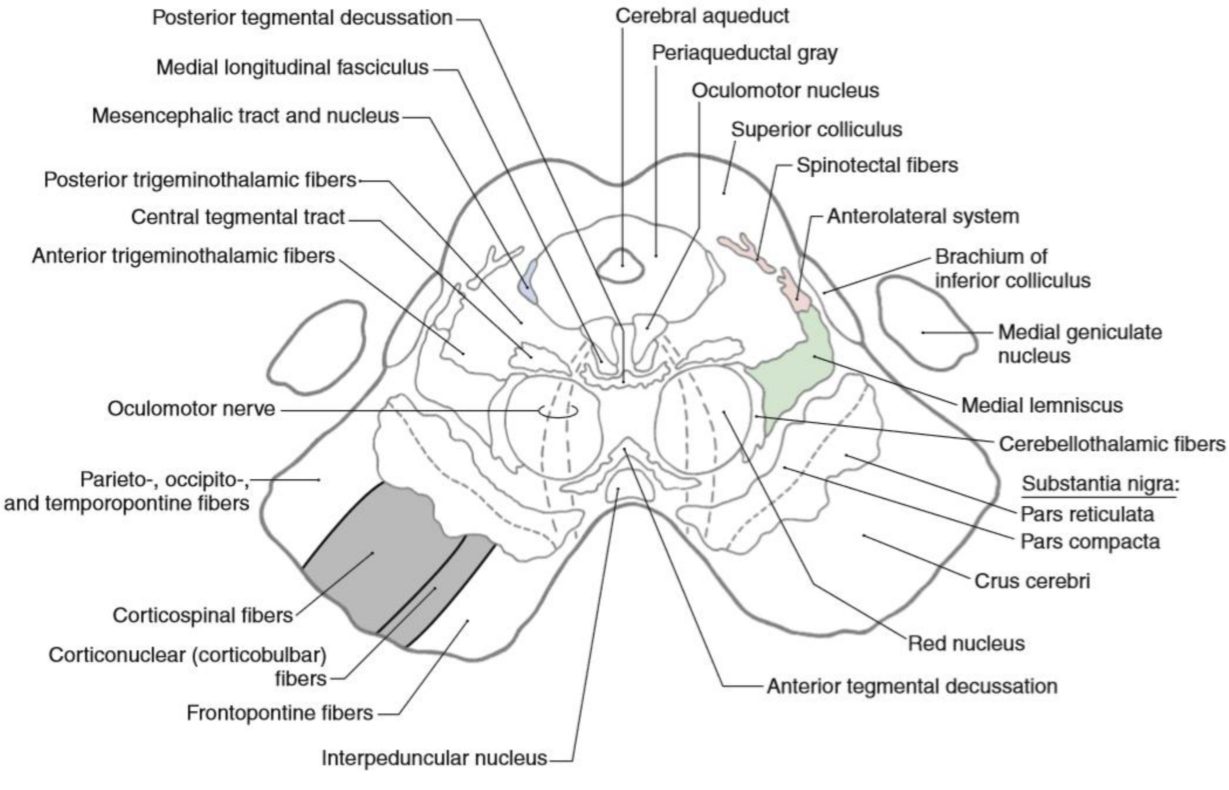
- 2 cranial nerves are associated with the midbrain – C.N. 3 and C.N. 4.

1. C.N. 3 – oculomotor nerve: SM, VM.
    - Function:
      innervate extra-ocular muscles – Superior, Medial and Inferior rectus, inferior oblique and the Levator Palpebrae Superioris.
    - Nucleus:
      Oculomotor nucleus – SM.
      Location: periaqueductal gray matter of midbrain, anterior to the aqueduct, at the level of superior colliculus.
      input: Corticonuclear, Tectobulbar – from superior colliculus.
      *Anterior to it passes the medial longitudinal fasciculus, that forms communication between C.N. 3,4,6.
    - Nerve:
      Oculomotor nerve: cross the red nucleus, exit the midbrain through the interpeduncular fossa, between the posterior cerebral and superior cerebellar arteries, pass at the lateral wall of cavernous sinus and then pass through the superior orbital fissure (has superior and inferior rami) and supply 5 extraocular muscles – superior inferior and medial rectus, inferior oblique and Levator Palpebrae Superioris.

    - Edinger-Westphal nucleus – VM. Also called ‘accessory parasympathetic nucleus’. Related to the activity of the oculomotor nucleus and found adjacent to it.
        - Location: posterior to oculomotor nucleus.
        - Function: PNS fibers to intrinsic muscles of the eye. controls the size of the lens and constricts the pupil.
        - input: from cortex.
        - Output: control the ciliary muscle and sphincter pupillae.
        - fibers from Edinger-westphal nucleus: travel with the ipsilateral oculomotor nerve and terminate in the ciliary ganglion. postganglionic fibers travel through the short ciliary nerve, to supply ciliary muscle and sphincter pupillae muscle of iris.

2. C.N. 4 – Trochlear nerve: SM.
    - Function: supply the **contralateral** superior oblique muscle.
    - Nucleus: anterior to central gray matter, level of inferior colliculus.
      input: 1) hemispheres, through corticonuclear fibers.
      2) Visual cortex – Tectobulbar fibers.
      3) Connection with C.N. 3,6 by the medial longitudinal fasciculus.
    - Nerve: the only C.N. that exit the midbrain posteriorly.
      only nerve which has crossed fibers – from the nucleus the fibers surround the periaqueductal gray matter, decussate as it exits the midbrain next to the inferior colliculus. Then it turns anteriorly to pass through the lateral wall of the cavernous sinus. exit to orbit through the superior orbital fissure.


Decussation of trochlear fibers
Inferior colliculus
Trochlear nerve
Periaqueductal gray matter
Trochlear nucleus
Basis pedunculi
Decussation of superior cerebellar peduncles


Posterior tegmental decussation
Medial longitudinal fasciculus
Mesencephalic tract and nucleus
Posterior trigeminothalamic fibers
Central tegmental tract
Anterior trigeminothalamic fibers
Oculomotor nerve
Parieto-, occipito-, and temporopontine fibers
Corticospinal fibers
Corticonuclear (corticobulbar) fibers
Frontopontine fibers
Interpeduncular nucleus
Cerebral aqueduct
Periaqueductal gray
Oculomotor nucleus
Superior colliculus
Spinotectal fibers
Anterolateral system
Brachium of inferior colliculus
Medial geniculate nucleus
Medial lemniscus
Cerebellothalamic fibers
Substantia nigra:
Pars reticulata
Pars compacta
Crus cerebri
Red nucleus
Anterior tegmental decussation

Brainstem at the level of inferior colliculus

Topic 7 – Surface anatomy of the cerebellum

Hain's 158, 370. Barr 159.

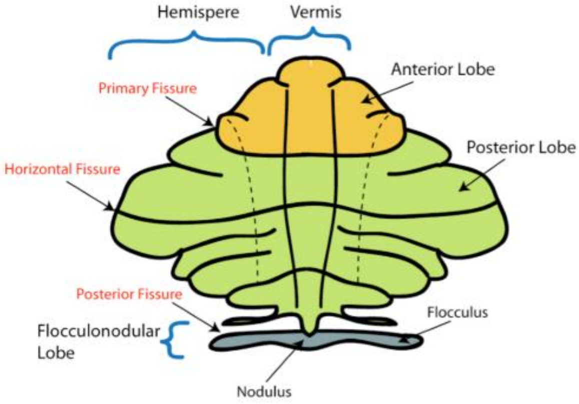
General:

- Cerebellum in latin means little brain. It is very important for motor functinos.
- Develop from rhombic lips of the pontine alar plates.
- It's about 10% of the wight of the CNS but contains over 50% of the neurons.
- Location: on the posterior cranial fossa, it is the posterior aspect of the brain. below the occipital lobe and behind the brain stem (the cerebellum covers the 4th ventricle).
- Transverse cerebral fissure separates the cerebellum from the telencephalon. the tentorium cerebelli is an extantion of the dura matter that is found in that fissure.
- 3 main Functions: (1) maintain posture. (2) maintain muscle tone. (3) coordinate voluntary motor activity.
- Cerebellar peduncles – 3 big fiber bundles that connect the cerebellum to the parts of brain stem. Through them it connects to all parts of the CNS:
    - Superior cerebellar peduncle – connect to the midbrain.
    - Middle cerebellar peduncle – connect to pons.
    - Inferior cerebellar peduncle – connect to medulla.
- Arbor vitae – tree of life. The shape of cerebellum in midsagittal section.

Parts of cerebellum:

divided to 3 lobes according to 3 classifications, that partly (**not completely**) overlap with each other:

Anatomical	Phylogenetical	Functional	Tracts
Anterior lobe. superiorly	Paleocerebellum – new. **Only vermis, no hemisphere**	Spinocerebellum – (vermis) adjustment of movement according to inputs: visual, proprioceptional.	From: dorsal columns, spinocerebellar, CN 5, visual and auditory systems. To: cerebella nuclei > descending tracts. (vermis – trunk + proximal limb, paravermal – distal limb).
Posterior lobe	Neocerebellum – newest. **Only hemisphere, no vermis**	Cerebrocerebellum – (hemispheres) fine tuning and planning of movement. also called pontocerebellum.	From: cortex and pontine nuc., To: VL nuc. Of thalamus, and red nuc.
Floculonodular lobe. inferiorly.	Archicerebellum – oldest.	Vestibulocerebellum – posture, balance, eye movement, muscle tone.	1. From vestibule, via med. + lat. Vestibular nuclei. 2. from sup. Colliculi, and visual cortex.



Structures of cerebellum:

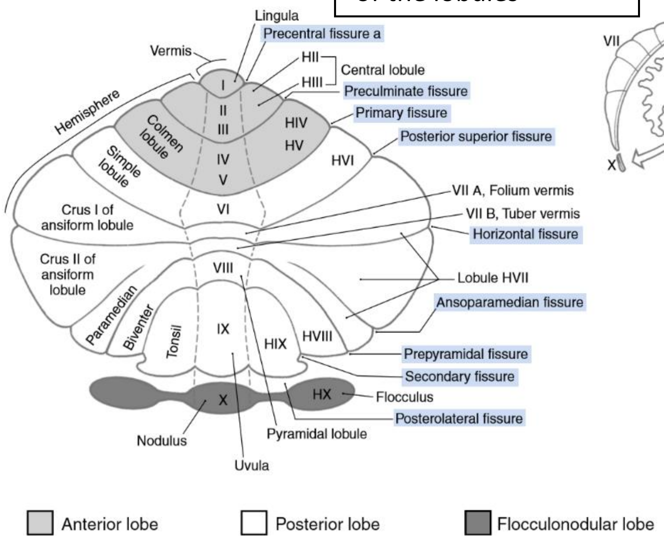
- **Vermis** – The middle part of the cerebellum. On its sides are the 2 **cerebellar hemispheres**. The **paravermal (intermediate) zone** is the medial part of each hemisphere.
  the 2 have corresponding parts.
- The cerebellum has many small gyri, called folia (folium). The sulci are called fissures.
- the fissures are shallow. Only the few fissures that separate the lobules are deep.
- 3 main lobes are separated by fissures –
  (1) Primary fissure – the deepest. between the anterior and posterior lobes.
  (2) Posterolateral fissure – more shallow. Separate the posterior and floculonodular lobes.
  (3) Horizontal lobe – in the middle of posterior lobe.
- 10 lobules: the important are underlined.

Vermis	hemisphere
1. Lingula cerebelli	--- (no equivalent)
2. Lobulus centralis (considerd 2+3).	Wing (ala) of central lobe
4. Culmen	Anterior quadrangular lobule
5. Declive	Posterior quadrangular lobule
6. Folium	Superior semilunar lobule
7. Tuber	Inferior semilunar lobule
8. Pyramis	Biventral lobule
9. Uvula	Tonsil of cerebellum
10. Nodulus	Flocculus

Main lobules:

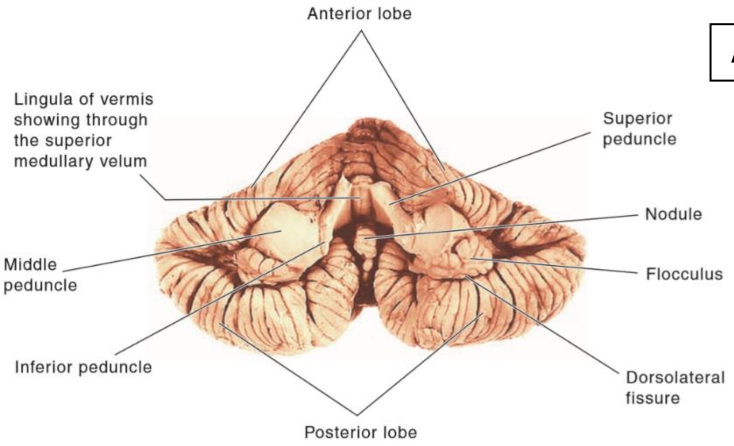
1. Lingula – attached to the superior medullary velum. Watching cerebellum posteriorly, after removing the rest of the cerebellum, it is very smilar to a tongue.
2. Nodule – last lobule of the cerebellum. continuous with the flocculus of hemispher.
   few cranial nerves are adjacent to the flocculus:
   1. Facial nerve medially.
   2. Vestibulocochlear laterally.
   3. intermediate nerve between the 2 others.
3. Uvula – posterior-inferior to the nodule. Correspond to tonsil of the hemisphere. At the level of foramen magnum.

**anatomical division of the lobules

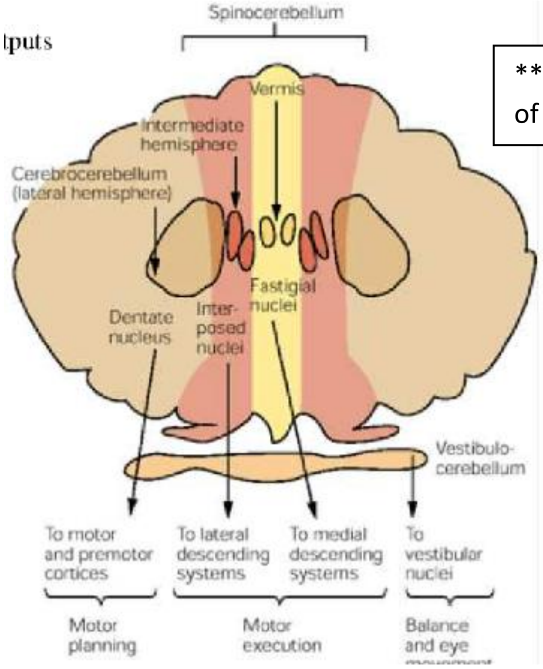

Lingula
Precentral fissure a
Vermis
HII
HIII
Central lobule
Preculminate fissure
Primary fissure
Posterior superior fissure
Hemisphere
Colmen lobule
Simple lobule
I
II
III
IV
V
HIV
HV
HVI
VI
Crus I of ansiform lobule
VII A, Folium vermis
VII B, Tuber vermis
Horizontal fissure
Crus II of ansiform lobule
VIII
Lobule HVII
Ansoparamedian fissure
Paramedian
Biventer
Tonsil
IX
HIX
HVIII
Prepyramidal fissure
Secondary fissure
X
HX
Flocculus
Posterolateral fissure
Nodulus
Pyramidal lobule
Uvula
VII
X
Anterior lobe
Posterior lobe
Flocculonodular lobe

Additional structures:

- Vallecula (valley) – Midline depression on the inferior aspect of the cerebellum.
- Superior, middle and inferior cerebellar peduncles – mentioned in topic 8.
- Tonsils – clinically significant. They are part of cerebellar hemispheres, close to medulla, and might compress it in case of increased intracranial pressure, as they are pushed into the foramen magnum. Breathing centers in medulla might be damaged.

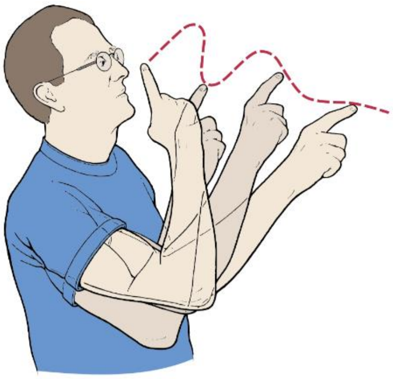

Anterior lobe
Lingula of vermis showing through the superior medullary velum
Superior peduncle
Nodule
Middle peduncle
Flocculus
Inferior peduncle
Dorsolateral fissure
Posterior lobe

Anterior view


tputs
Spinocerebellum
Vermis
Intermediate hemisphere
Cerebrocerebellum (lateral hemisphere)
Fastigial nuclei
Dentate nucleus
Inter-posed nuclei
Vestibulo-cerebellum
To motor and premotor cortices
To lateral descending systems
To medial descending systems
To vestibular nuclei
Motor planning
Motor execution
Balance and eye

**Functional division of the lobules

**אם הסרבלום נפגע
קשה לחטט באף



Pathways: *not very important for the anatomy exam. You can remember these main examples.

1) Vestibulocerebellar pathway:

- Function: maintain posture, balance and the coordination of eye movements.
- Receives its major input from the vestibular receptors of the kinetic and static labyrinths.
- Involves communication of:
  1. Semicircular ducts and otolith organs.
  2. Flocculonodular lobe.
  3. Vestibular nuclei:
     - project via the medial longitudinal fasciculi (MLFs) to the ocular motor nuclei of CN III, IV and VI to coordinate eye movements.
     - project via the medial and lateral vestibulospinal tracts to the spinal cord to regulate neck and antigravity muscles.

2) Vermal spinocerebellar pathway

- Function: Maintns muscle tone and postural control over truncal (axial) and proximal (limb gridle) muscles.
- Involves communication of:

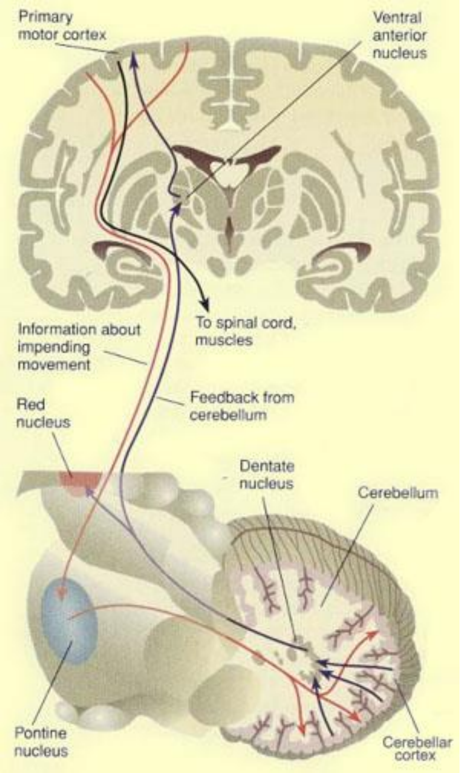
  1. Vermis:
     - Spinocerebellar and labyrinth input.
  2. Fastigial nucleus:
     - projects via to the spinal cord and thalamus.
  3. precentral gyrus:
     - Origin of ventral corticospinal tract – regulates muscle tone of truncal and proximal muscles.

3) Paravermal spinocerebellar pathway

- Function: Maintains muscle tone and postural control over distal muscle groups.
- Involves communication of:

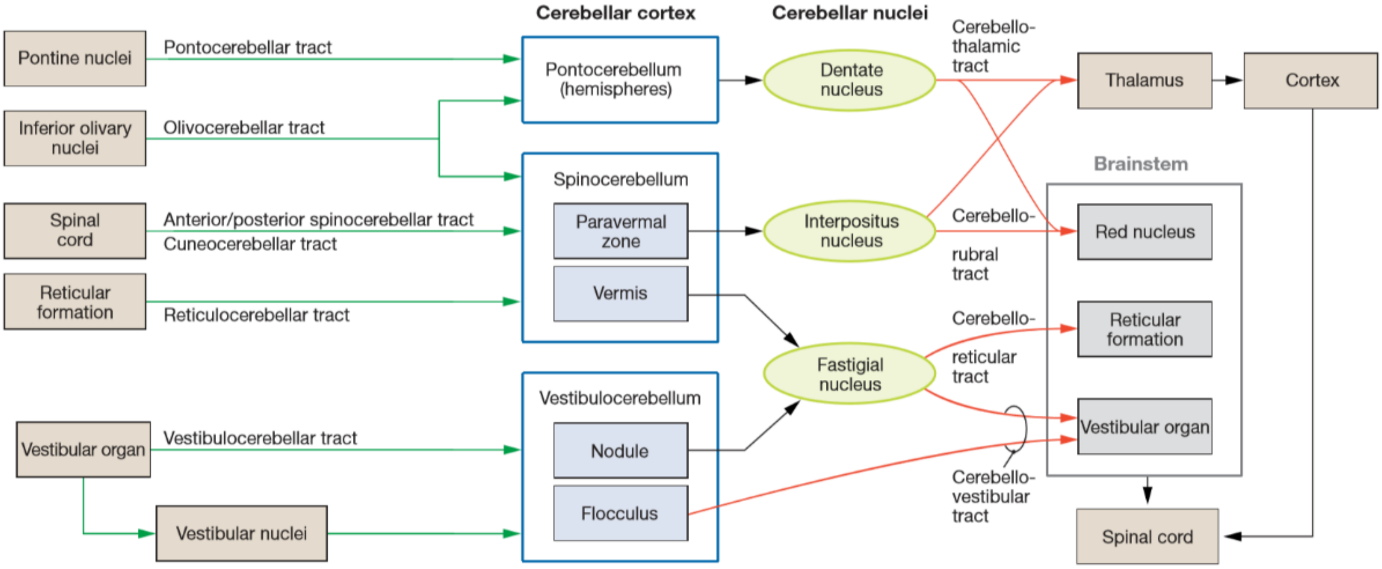
  1. Paravermis:
     - receives spinocerebellar input from distal muscles.
     - projects to the interposed nuclei.
  2. Interposed nuclei (emboliform and globose).
  3. Ventral lateral nucleus – projects to the extremities area of the precentral gyrus, which gives rise to the lateral corticospinal tract which regulates distal muscle groups.
  4. red nucleus – gives rise to the crossed rubrospinal tract which mediates control over distal muscles.

4) Lateral hemispheric cerebellar pathway:


Primary motor cortex
Ventral anterior nucleus
Information about impending movement
To spinal cord, muscles
Red nucleus
Feedback from cerebellum
Dentate nucleus
Cerebellum
Pontine nucleus
Cerebellar cortex

- Also called neocerebellar/pontocerebellar pathway.
- Regulates the initiation, planning and timing of motor activity.
- Involves communication of:

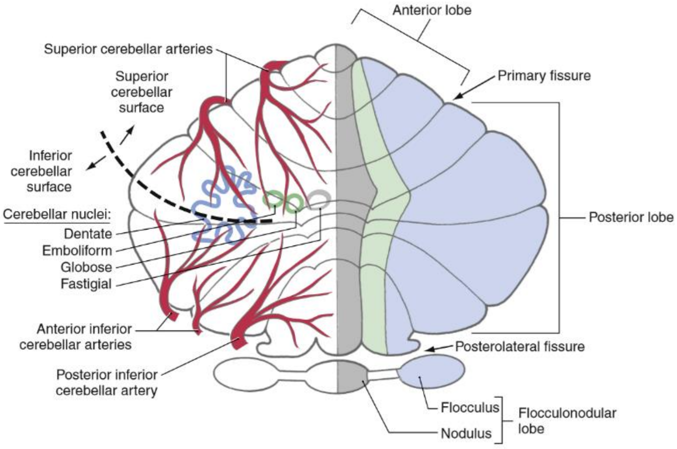
  1. cerebellar hemisphere
     - receives input from the contralteral motor and sensory cortex via the corticopontocerebellar tract.
     - projects via purkinje cell axons to the dentate nucleus.
  2. dentate nucleus:
     - projects vie the superior cerebellar peduncle to the contralateral red nucleus, ventral lateral nucleus of thalamus and the inferior olivary nucleus.
  3. red nucleus + inferior olivary pathway:
     - Projects to the inferior olivary nucleus.
     - the inferior olivary nucleus porjects via the contralateral inferior cerebellar peduncle to the cerebellum.
  4. ventral lateral nucleus pathway
     - the ventral lateral nucleus of the thalamus projects to the motor (4) and premotor (6) cortices.
     - the motor and premotor cortices give rise to the following tracts:
       a) Corticobulbar **–** innervates CN nuclei.
       b) Lateral corticospinal tract – regulates volitional synergistic motor activity.
       c) Corticopontocerebellar tract – regulates the output of the neocerebellum.

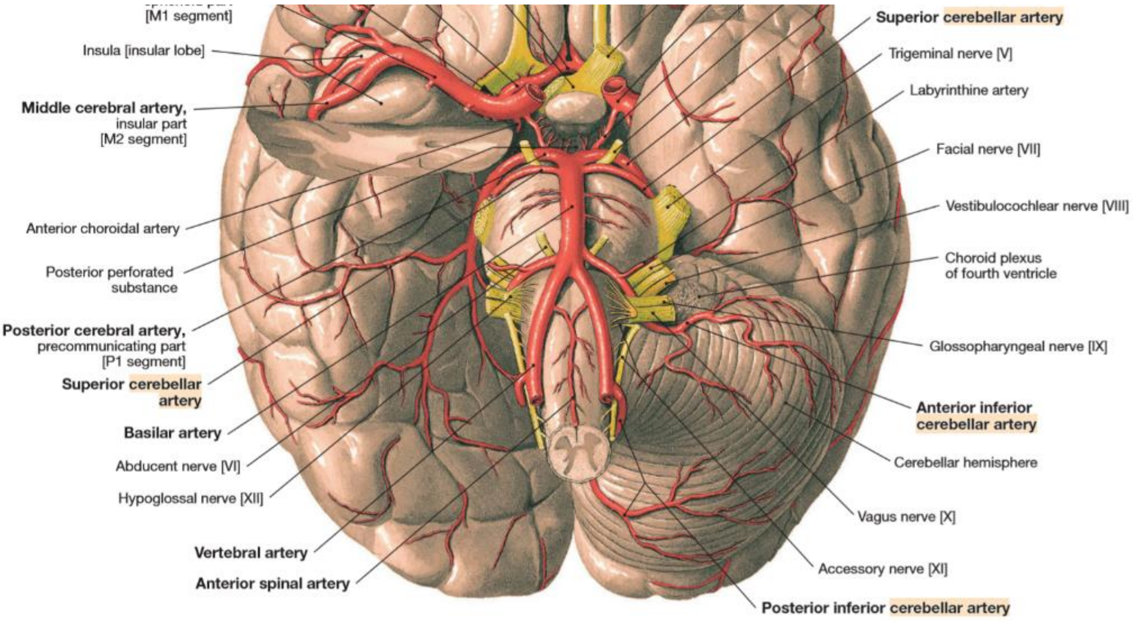

Cerebellar cortex
Cerebellar nuclei
Pontine nuclei
Pontocerebellar tract
Pontocerebellum (hemispheres)
Dentate nucleus
Cerebello-thalamic tract
Thalamus
Cortex
Inferior olivary nuclei
Olivocerebellar tract
Spinocerebellum
Brainstem
Spinal cord
Anterior/posterior spinocerebellar tract
Cuneocerebellar tract
Paravermal zone
Interpositus nucleus
Cerebello-rubral tract
Red nucleus
Reticular formation
Reticulocerebellar tract
Vermis
Fastigial nucleus
Cerebello-reticular tract
Reticular formation
Vestibulocerebellum
Vestibular organ
Vestibulocerebellar tract
Nodule
Vestibular organ
Cerebello-vestibular tract
Vestibular nuclei
Flocculus
Spinal cord

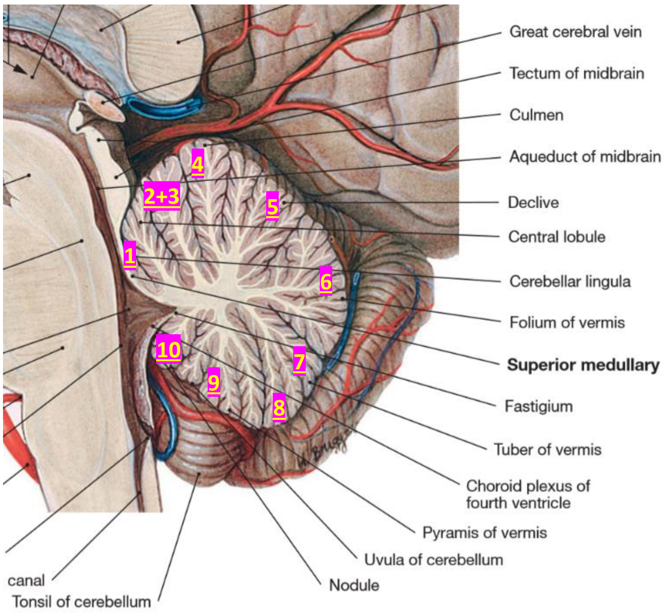
Topic 8 – Arteries of the cerebellum. Demonstration of the structures on the midsagittal section of the cerebellum. Cerebellar peduncles (list of tracts is optional), cerebellar nuclei.

Blood vessels of the cerebellum:

- The blood supply to the cerebellum originate from the vertebral-basilar system.
- 3 main branches supply the cerebellum –
  1. P.I.C.A. – posterior inferior cerebellar artery. Originate from the vertebral artery.
     Supply:
     (1) medial inferior surface,
     (2) nodule,
     (3) choroid plexus of 4th ventricle,
     (4) medulla – posterolateral part.
  2. A.I.C.A. – anterior inferior cerebellar artery. Branch of basilar artery.
     Supply:
     (1) lateral inferior surface,
     (2) dentate nucleus,
     (3) middle and inferior cerebellar peduncle,
     (4) Choroid plexus in the cerebellopontine angle (junction of pons-medulla-cerebellum).
     (5) inner ear, through its branch labyrinthine artery (sometimes branch of basilar a.).
  3. Superior cerebellar artery – from the basilar artery. Supply:
     (1) superior surface of the cerebellum,
     (2) cerebellar nuclei,
     (3) superior and middle cerebellar peduncles,
     (4) the midbrain.


Anterior lobe
Superior cerebellar arteries
Superior cerebellar surface
Primary fissure
Inferior cerebellar surface
Cerebellar nuclei:
Dentate
Emboliform
Globose
Fastigial
Posterior lobe
Anterior inferior cerebellar arteries
Posterolateral fissure
Posterior inferior cerebellar artery
Flocculus
Nodulus
Flocculonodular lobe


[M1 segment]
Insula [insular lobe]
Middle cerebral artery, insular part [M2 segment]
Anterior choroidal artery
Posterior perforated substance
Posterior cerebral artery, precommunicating part [P1 segment]
Superior cerebellar artery
Basilar artery
Abducent nerve [VI]
Hypoglossal nerve [XII]
Vertebral artery
Anterior spinal artery
Superior cerebellar artery
Trigeminal nerve [V]
Labyrinthine artery
Facial nerve [VII]
Vestibulocochlear nerve [VIII]
Choroid plexus of fourth ventricle
Glossopharyngeal nerve [IX]
Anterior inferior cerebellar artery
Cerebellar hemisphere
Vagus nerve [X]
Accessory nerve [XI]
Posterior inferior cerebellar artery


4
2+3
5
1
6
10
7
9
8
Great cerebral vein
Tectum of midbrain
Culmen
Aqueduct of midbrain
Declive
Central lobule
Cerebellar lingula
Folium of vermis
Superior medullary
Fastigium
Tuber of vermis
Choroid plexus of fourth ventricle
Pyramis of vermis
Uvula of cerebellum
Nodule
canal
Tonsil of cerebellum

Mediansagittal section of the cerebellum:

On the cross section we can recognize all the lobules of the vermis. This presentation is called the Arbor Vitae, because it is similar to the shape of the leaf of that tree.

1. Lingula cerebelli.
2+3. Central lobule.
4. Culmen.
5. Declive.
6. Folium.
7. Tuber.
8. Pyramis.
9. Uvula.
10. Nodulus.

Main lobules:

1. Lingula – attached to the superior medullary velum.
   watching cerebellum posteriorly, after removing the rest of the cerebellum, it is very smilar to a tongue. Corresponds to vinculum lingulae lobule in the hemisphere.
2. Nodule – last lobule of the cerebellum. continuous with the flocculus of hemispher.
   together they make the floculonodular lobe.
   few cranial nerves are adjacent to the flocculus:
   a. Facial nerve medially.
   b. Vestibulocochlear laterally.
   c. intermediate nerve between the 2 others.
3. Uvula – posterior-inferior to the nodule. Correspond to Tonsilla Cerebelli of the hemisphere. At the level of foramen magnum.

Cerebellar peduncles:

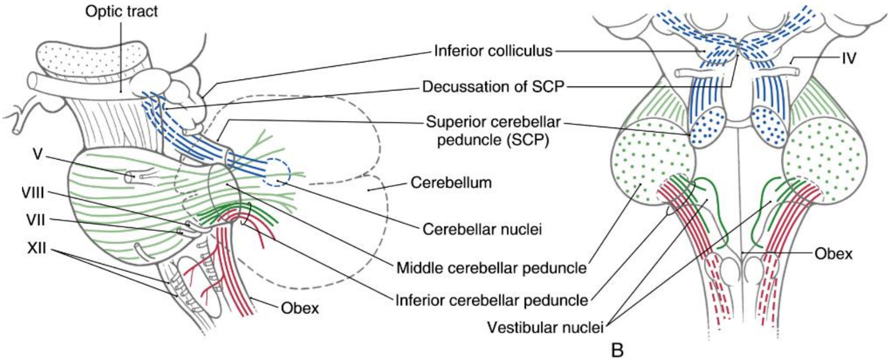
There are 3 peduncles that connect the cerebellum to the brain stem.
*there are many tracts that pass through the peduncles. Few examples are mentioned here.

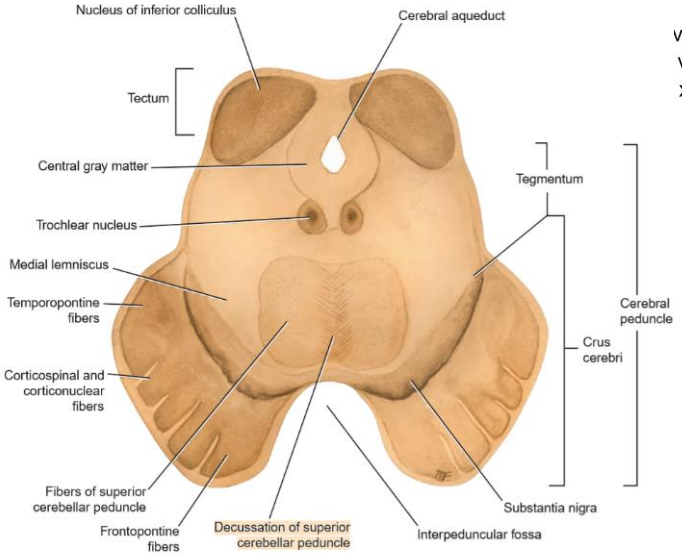
- Superior cerebellar peduncle – enter the midbrain next to the trochlear nerve.
  assists in formation of the roof of the 4th ventricle, together with the superior medullary velum.
  - Input: anterior spinocerebellar tract.
  - Output: efferent from all nuclei except fastigial. to thalamus, cortex and other places.

  **Please notice that the fibers ascend to cortex and decussate at the inferior colliculus level. The decussation is visible on one of the coronal section. It looks like 2 white circles (because these are axon), and you know it is not the red nucleus because the color of nuclei is gray.

- Middle cerebellar peduncle – enter the pons, on the sides of the rhomboid fossa.
  C.N. 5 marks the border between the middle peduncle and the pons.
  - Input: Raphecerebellar (from nucleus raphe) and pontocerebellar (cortex > pontine nuclei > cerebellum).
  - Output: Non.

- Inferior cerebellar peduncle – enter the medulla.
  Has 2 parts:
  (1) Restiform body – larger, mainly fibers from spine and medulla.
  Main pathways: posterior spinocerebellar (proprioception, to anterior lobe, important for posture), olivocerebellar (inferior olive), reticulocerebellar.
  (2) Juxtarestiform body – fibers between cerebellum and vestibular structure.
  Main pathways: vestibulocerebellar (vestibular nuclei).
  Efferent from fastigial nucleus, to vestibular nuclei and other places.


Optic tract
Inferior colliculus
Decussation of SCP
Superior cerebellar peduncle (SCP)
Cerebellum
Cerebellar nuclei
Middle cerebellar peduncle
Inferior cerebellar peduncle
Vestibular nuclei
V
VIII
VII
XII
Obex
IV
Obex
B

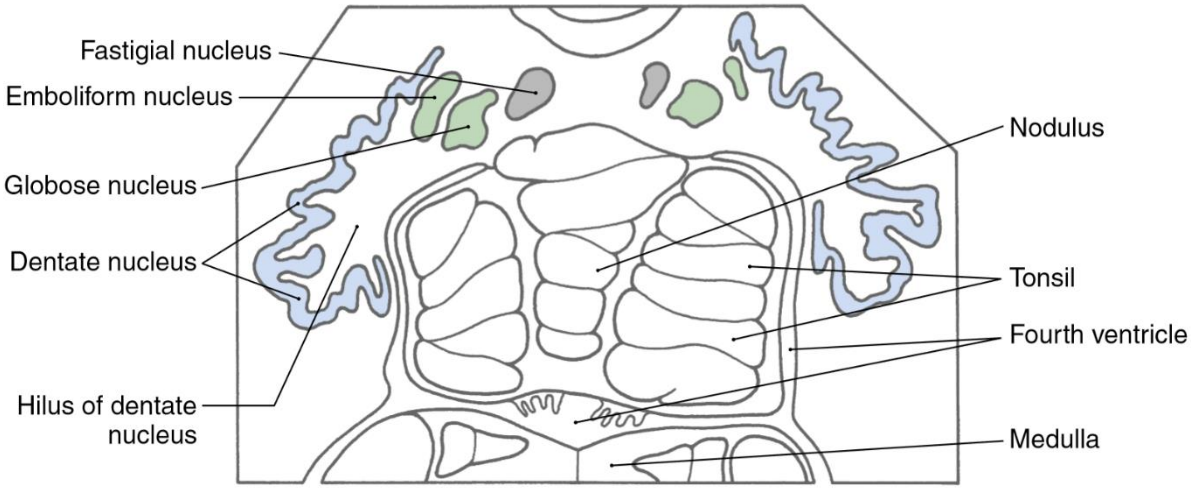

Nucleus of inferior colliculus
Cerebral aqueduct
Tectum
Central gray matter
Trochlear nucleus
Tegmentum
Medial lemniscus
Temporopontine fibers
Cerebral peduncle
Crus cerebri
Corticospinal and corticonuclear fibers
Fibers of superior cerebellar peduncle
Frontopontine fibers
Decussation of superior cerebellar peduncle
Interpeduncular fossa
Substantia nigra

Cerebellar nuclei:

- There are 4 nuclei on each side, found deep in the cerebellum. They receive input from purkinje cells and from afferent fibers into the cerebellum.
- They are excitatory, use glutamate and aspartate neurotransmitters.
- Most of the fibers that leave the cerebellum are from the nuclei, but little are from the cortex, and they are inhibitory (GABA).
- Only the dentate can somehow be really seen macroscopically.

The nuclei (medial to lateral):

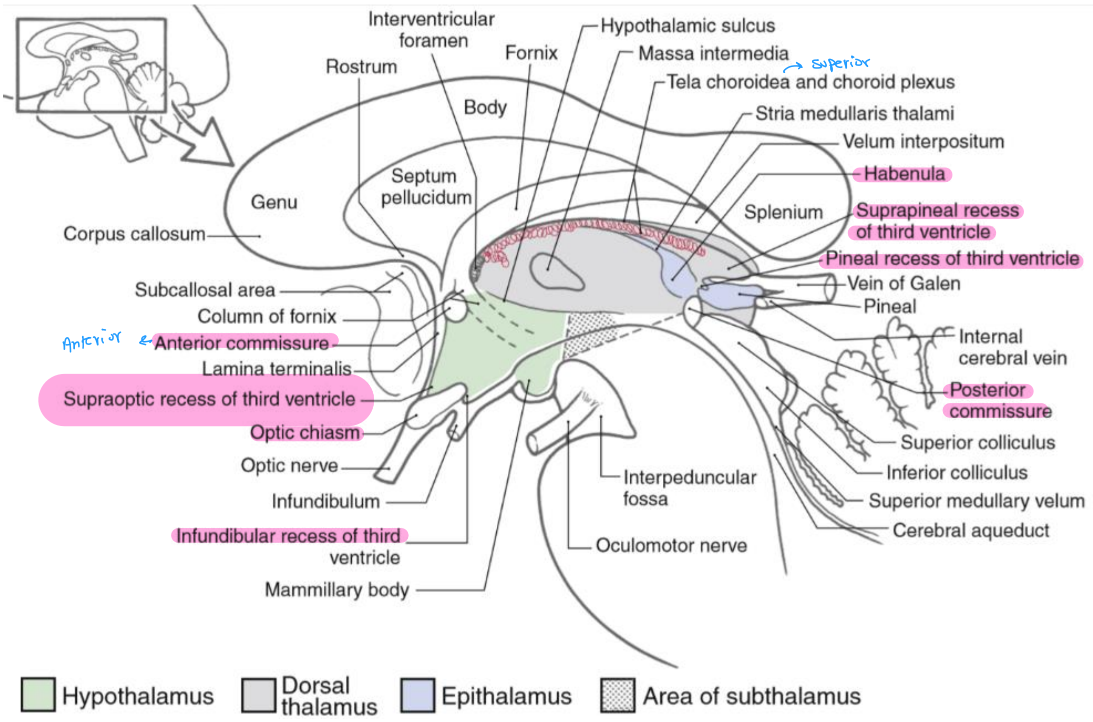
- Fastigial – Fibers Exit through the Juxtarestiform bodies of the inferior cerebellar peduncle. Functions mainly with the Vestibulocerebellum and Vermal area.
- Globus – Fibers exit through the superior cerebellar peduncle. Functions mainly with the Spinocerebellum and intermediate (paravermal) cortex.
- Emboliform – Fibers exit through the superior cerebellar peduncle.
  Together with the Globus forms the interposed nucleus.
  Functions mainly with the Spinocerebellum and intermediate (paravermal) cortex.
- Dentate – the biggest. Has a tooth shape. Functions mainly with the cerebrocerebellum and cerebral cortex. Hilus – its opening, directed anteromedially.
  Fibers exit through the superior cerebellar peduncle.


Fastigial nucleus
Emboliform nucleus
Globose nucleus
Dentate nucleus
Hilus of dentate nucleus
Nodulus
Tonsil
Fourth ventricle
Medulla

Topic 9 – Parts of the diencephalon (excluding the third ventricle)

Hain's 198 giving info. of right part of brain

- Position: between the telencephalon and the brain stem. Deepest part of forebrain.
- Diencephalon cavity: 3rd ventricle.
- Development: from Prosencephalon. The telencephalon develops faster, so it covers the diencephalon.
- Include 5 parts – Thalamus, Hypothalamus, Subthalamus, Metathalamus and Epithalamus.


Interventricular foramen
Hypothalamic sulcus
Fornix
Massa intermedia
superior
Rostrum
Tela choroidea and choroid plexus
Body
Stria medullaris thalami
Velum interpositum
Habenula
Septum pellucidum
Genu
Splenium
Suprapineal recess of third ventricle
Corpus callosum
Pineal recess of third ventricle
Vein of Galen
Subcallosal area
Pineal
Column of fornix
Anterior
Anterior commissure
Internal cerebral vein
Lamina terminalis
Supraoptic recess of third ventricle
Posterior commissure
Optic chiasm
Superior colliculus
Optic nerve
Inferior colliculus
Interpeduncular fossa
Infundibulum
Superior medullary velum
Infundibular recess of third ventricle
Cerebral aqueduct
Oculomotor nerve
Mammillary body
Hypothalamus
Dorsal thalamus
Epithalamus
Area of subthalamus

1) Thalamus: also called dorsal thalamus.

- Largest part of diencephalon. One on each side.
- Function:
  grey matter
  1) it is a big relay station. its nuclei receive input, process it, and send it to cortex. The cortex interprets the sensation information that pass through the thalamus. The only input that does not enter the thalamus directly is the olfactory input (smell).
  2) important for voluntary movement. It is part of the motor loop.
- Surrounding structures:
  - superiorly: body of lateral ventricle, body of caudate nucleus, fornix. On its superior surface – Thalamostriate vein (terminal vein), Lamina Affixa Thalami, Tenia Thalami of 3rd ventricle and Tenia Choroidea + Tenia Fornicis of lateral ventricle.
  - inferiorly: tegmentum of midbrain, hypothalamus and subthalamus.
  - posteriorly: pineal gland.
  - medially: forms the lateral walls of the 3rd ventricle.
  - laterally: internal capsule.
- Covered by thin white matter – stratum zonale dorsally, external medullary lamina laterally.
- The 2 thalami are connected by interthalamic adhesion, also called intermediate mass.

Y shape
Ant, medial, lateral

Classification of nuclei of thalamus according to position:

- Thalamus is composed of many nuclei, each is part of different pathways. These nuclei are divided to 3 groups by thing layer of white matter – internal medullary lamina – anterior, medial, lateral.   in addition, few other nuclei don't belong to any of these groups.

  1. Anterior group:
  - Contains the anterior thalamic nuclei.
    Function: work with the limbic system, responsible for emotion and recent memory.
    Communication: receive Mammillothalamic tract (→ vicq d'Azyr tract) from mammillary bodies, and send the fibers to cingulate gyrus and hypothalamus. part of Papez circuit.

  2. Medial group:
  - This part is responsible for integration of a large variety of sensory information. Takes part in pathways of all senses beside olfaction. Connect to amygdala.
  - dorsomedial nucleus is the main one. It has a 2-way connection with the prefrontal cortex, and similar connection hypothalamic nuclei. Also connect to all other thalamic nuclei.

  3. Lateral group:
  - Divided into dorsal and ventral trier:
    Dorsal trier(שלישייה): communicate with the other thalamic nuclei. It includes:
    - ✈ Lateral dorsal (LD).
    - ✈ Lateral posterior (LP).
    - ✈ Pulvinar (caudal-most nucleus of thalamus).

    *Ventral trier: → Acoustic & visual pathway
    - ✈ Ventral anterior (VA) – composed of parvocellular and magnocellular parts. Connect to reticular formation, Substantia nigra and premotor cortex, part of pathway that include corpus striatum and motor cortex.
      function: motor activity.
    - ✈ Ventral lateral (VL) –
      connects to the red nucleus and premotor cortex.
      function: motor activity.
    - ✈ Ventral posterior (VP) – divided into ventral posteromedial (VPM) & ventral posterolateral (VPL) nuclei. from them, thalamocortical fibers go to 1° somatic sensory fibres in postcentral gyrus.
      VPM – receive spinal trigeminal nucleus and trigeminal and gustatory pathways. Gives sensory information of the head and neck.
      VPL – receive information from medial and spinal lemnisci, part of dorsal column-lateral lemniscus system. Gives sensory information of the body, except for the head and neck.
    - ✈ Ventral intermediate nucleus.

Additional nuclei:

- Interlaminar nuclei: found in the internal medullary lamina. Recieve fibers from reticular formation, spinothalamic & trigeminothlamic tracts. Fibres then go to other thalamic nuclei. Function believed to be at level of consciousness.

- Midline nuclei: In the interthalamic connection. Receive fibres from reticular formation.

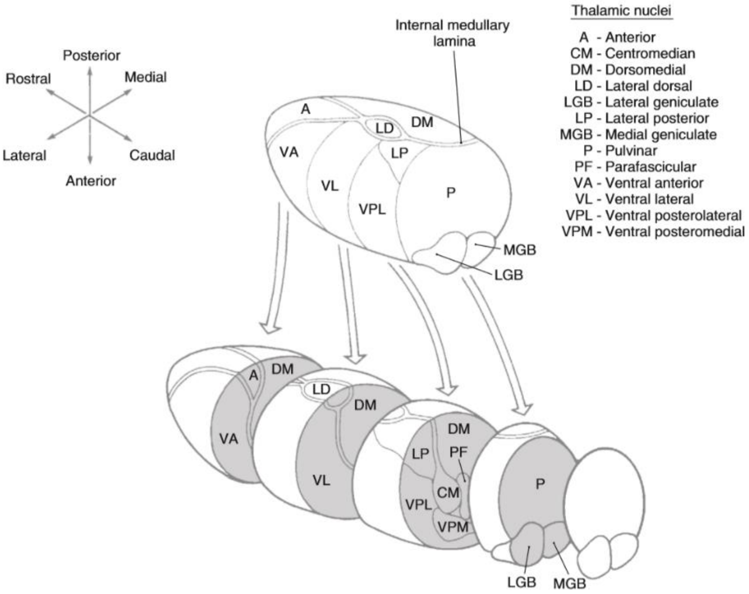
- Reticular nucleus: Thin layer btw external medullary lamina and posterior limb of internal capsule. Function not fully understood.

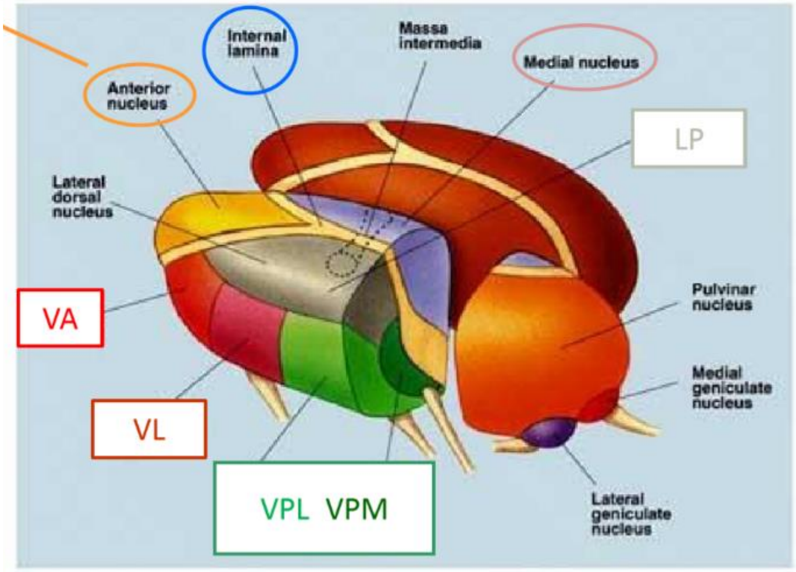
Medial and lateral geniculate bodies, sometimes considered as another part of diencephalon – Metathalamus, are part of the lateral group of nuclei, and participate in pathways.

- Medial geniculate body:
  swelling on posterior surface, beneath Pulvinar.
  Part of the auditory pathway – Receives fibers from inferior colliculus (from lateral lemniscus), mainly from the contralateral ear. fibers leave through the auditory radiation and go to the auditory cortex in superior temporal gyrus.
- Lateral geniculate body:
  swelling under the Pulvinar. It has 6 layers of nerve cells. Most fibers of the optic tract pass through it (except those going to pretectal nucleus).
  Part of the visual pathway –
  Input: fibers from ganglion cell layer of the retina (temporal half of ipsilateral eye + nasal half of contralateral eye). Output: to the visual cortex in the occipital lobe.

- Classification of nuclei of thalamus according to Function:
  - Sensory relay nuclei (specific): part of tracts that receive somatosensory input to cortex.
    - ✈ VPL, VPM – input: somatosensory info of body – from medial lemniscus (VPL), somatosensory info of head – trigeminal lemniscus (VPM).
      Output: primary somatosensory cortex.
    - ✈ Lateral geniculate body – Input: Optic tract, Output: primary visual cortex.
    - ✈ Medial geniculate body – Input: lateral lemniscus, Output: auditory cortex.

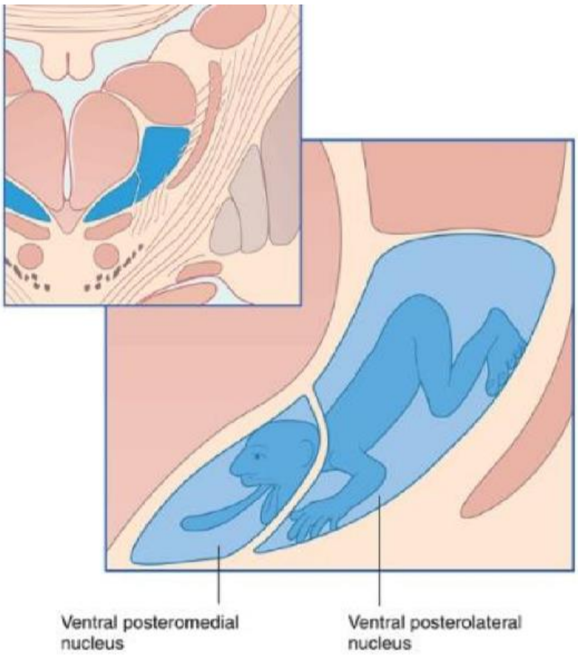
  - Cortical relay nuclei (specific):
    - ✈ Anterior nuclei (AV, AD, AM) – Part of Papez circuit (memory).
      Input: mammillary body (Mammillothalamic tract). Output: cingulate gyrus.
    - ✈ VA, VL – Part of motor cortex-basal ganglia planning pathway.
      Input: cerebellum, Globus Pallidus, substantia nigra.
      Output: prefrontal cortex (supplementary motor, responsible for attention).
  - Non-specific nuclei:
    - ✈ Intralaminar and midline nuclei (found in the internal medullary lamina).
      Input: cerebellum, spinal cord, reticular formation, hypothalamus, Globus Pallidus, cortex. Output: cortex.
    - ✈ Association nuclei: Pulvinar, DM, LP Input: diencephalon, Amygdaloid body.
      Output: association cortex (occipital, temporal).
    - ✈ Reticular nuclei: integration.


Posterior
Rostral
Medial
Lateral
Caudal
Anterior
Internal medullary lamina
Thalamic nuclei
A - Anterior
CM - Centromedian
DM - Dorsomedial
LD - Lateral dorsal
LGB - Lateral geniculate
LP - Lateral posterior
MGB - Medial geniculate
P - Pulvinar
PF - Parafascicular
VA - Ventral anterior
VL - Ventral lateral
VPL - Ventral posterolateral
VPM - Ventral posteromedial
A
DM
LD
LP
VA
VL
VPL
P
MGB
LGB
CM
PF
VPM


Internal lamina
Massa intermedia
Medial nucleus
Anterior nucleus
LP
Lateral dorsal nucleus
VA
Pulvinar nucleus
Medial geniculate nucleus
VL
VPL VPM
Lateral geniculate nucleus

Ventro-posteromedial (VPL) and ventro-posterolateral (VPM) nuclei show somatotoipc arrangement.

- The VPL receives sensory info from the body, through the dorsal column-medial lemniscus system.
- The VPM receives sensory info from the head through the trigeminal lemniscus.
- Both nuclei will send their output to the somatosensory cortex.

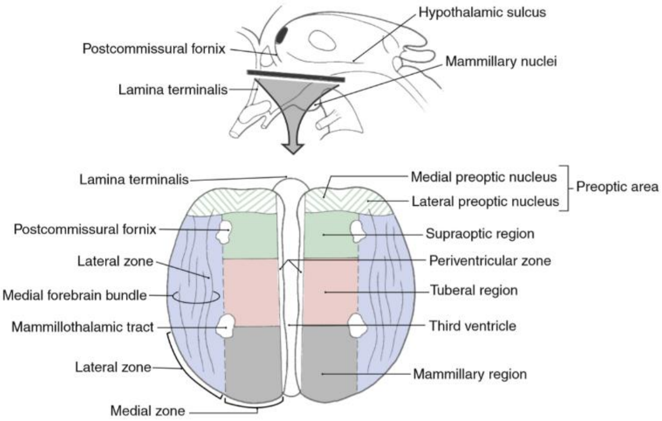

Ventral posteromedial nucleus
Ventral posterolateral nucleus

2) Hypothalamus

- Functions:
  1. Regulate homeostasis, by Controling endocrine and autonomic nervous systems.
     a. Regulate food and water intake – hunger Vs. satiety, control thirst.
     b. Regulate temperature and determines the set point.
  2. Effect emotion and behaviour together with the limbic system and prefrontal cortex.
  3. Control circadian rhythm with thalamus, limbic system, reticular activating system.
- Divided into 3 zones: lateral, medial, periventricular (+preoptic area on front).
- Borders:
  - Superior: thalamus. separated from it by hypothalamic groove.
  - Inferior: from anterior – optic chiasm, infundibulum + Tuber Cinereum, mammillary bodies.
  - Anterior: anterior commissure, Lamina Terminalis, optic chiasm.
  - Posterior: oblique line connecting posterior commissure to the mammillary body.
  - Medial: 3rd ventricle.
  - Lateral: telencephalon – substantia innominata and posterior limb of internal capsule.
- Regulate the activity of the Pituitary gland (hypophysis) found in the sella tursica (hypophyseal fossa).
- Recieves information by nerves, and by sensing blood and CSF.
- Please notice – there are 2 hypothalamus, 1 on each half of diencephalon, same as thalamus.

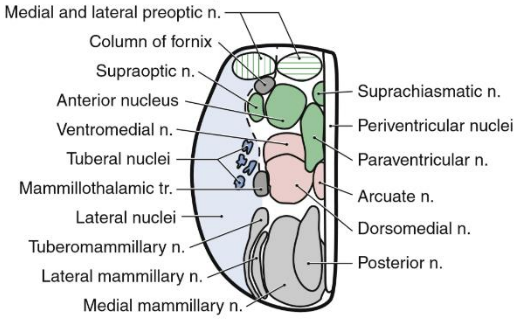
Nuclei: according to its 4 parts:

- Periventricular zone – periventricular nucleus.
- Medial zone: has 3 parts –
  1. Supraoptic (anterior) region: produce hormones for neurohypophysis.
     - Supraoptic nucleus (ADH),
     - Suprachiasmatic nucleus (circadian cycle),
     - Preoptic nucleus,
     - Paraventricular nucleus (oxytocin),
     - Anterior nucleus.
  2. Tuberal (medial) region: produce hormones for adenohypophysis (releasing or inhibitory).
     - Venteromedial nucleus,
     - Dorsomedial nucleus,
     - Arcuate nucleus.
  3. Mammillary region: releated to limbic system.
     - Mammillary nuclei (bodies) – Pair of round bodies. Gray matter, surrounded by white. posterior perforated substance is posterior to it.
     - Posterior hypothalamic nucleus.


Hypothalamic sulcus
Postcommissural fornix
Mammillary nuclei
Lamina terminalis
Lamina terminalis
Medial preoptic nucleus
Lateral preoptic nucleus
Preoptic area
Postcommissural fornix
Supraoptic region
Lateral zone
Periventricular zone
Medial forebrain bundle
Tuberal region
Mammillothalamic tract
Third ventricle
Lateral zone
Mammillary region
Medial zone

Green – supraoptic. Pink – tuberal. gray – mammillary. Blue – lateral

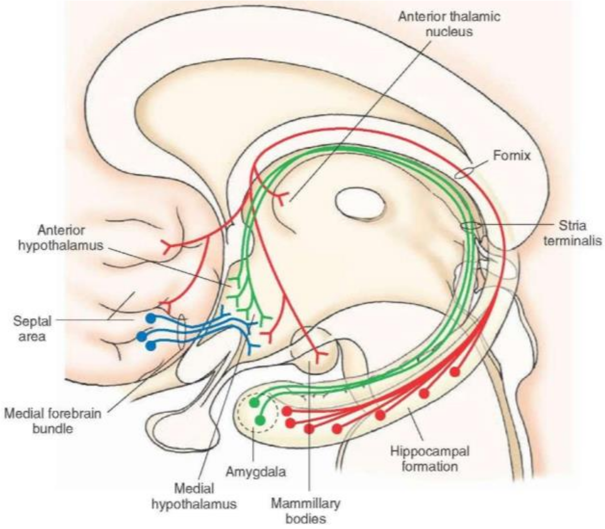
Key for nuclei


Medial and lateral preoptic n.
Column of fornix
Supraoptic n.
Anterior nucleus
Ventromedial n.
Tuberal nuclei
Mammillothalamic tr.
Lateral nuclei
Tuberomammillary n.
Lateral mammillary n.
Medial mammillary n.
Suprachiasmatic n.
Periventricular nuclei
Paraventricular n.
Arcuate n.
Dorsomedial n.
Posterior n.

- Lateral zone: mainly white matter.
  Medial Forebrain Bundle – pass throug the lateral zone. It is bidirectional tract – communicates with the brain stem, septal nuclei and other regions.

Nuclei (anterior to posterior):

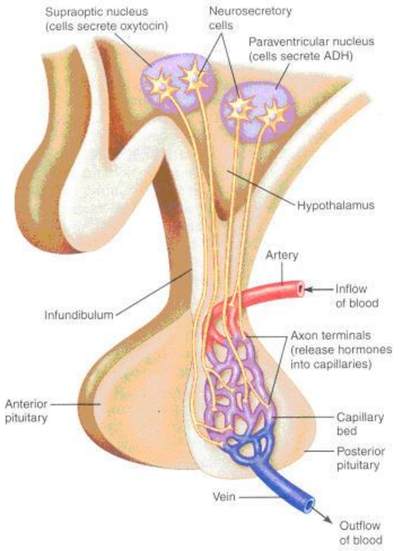
- Preoptic nucleus.
- Lateral nuclei.
- Tuberal nuclei.
- Tuberomammillary nucleus.


Anterior thalamic nucleus
Fornix
Stria terminalis
Anterior hypothalamus
Septal area
Medial forebrain bundle
Hippocampal formation
Amygdala
Medial hypothalamus
Mammillary bodies

Connections:

- Inputs:
  - Somatic and visceral: lemniscal afferent fibres and tractus solitarius.
  - Visual: optic chiasms → suprachiasmatic nucleus.
  - Olfaction: through medial forebrain bundle.
  - Corticohypothalamic fibres: from frontal lobe of cortex to hypothalamus.
  - Limbic system – Hippocampohypothalamic fibres: from hipocampus through fornix to mammillary body.
  - Limbic system – Amygdalohypothalamic fibres: through stria terminalis, route on the thalamus, next to the caudate nucleus.
  - Thalamohypothalamic fibres: from dorsomedial and midline nuclei.
  - Tegmental fibres: from midbrain.
  - Circumventricular organs – areas with more permeable blood brain barrier. They can sense blood component and indicate thalamus about the homeostatic status of the body.

- Outputs:
  - Descending fibres to the brainstem and spinal cord → peripheral neurons of the ANS (PNS & SNS) via reticular formation.
    PNS: Parasympathetic ganglia of CN III, VII, IX, X and lateral gray horn S2-S4.
    SNS: lateral gray horn T1-L2.
  - To papez circuit – Mammillothalamic tract: mammillary body > anterior thalamic nucleus > cingulate gyrus.
  - Dopaminergic reward system – Mammillotegmental tract: mammillary body > reticular formation.
  - Many connections to limbic system.


Supraoptic nucleus (cells secrete oxytocin)
Neurosecretory cells
Paraventricular nucleus (cells secrete ADH)
Hypothalamus
Artery
Inflow of blood
Infundibulum
Axon terminals (release hormones into capillaries)
Anterior pituitary
Capillary bed
Posterior pituitary
Vein
Outflow of blood

Relation with the pituitary gland (Hypophysis):

- Tuber Cinereum**:** gray matter between mammillary bodies and optic chiasms. Infundibulum emerge from it.
- Median eminence: bulge on the Tuber Cinereum. Median eminence, infundibulum and pars nervosa form the neurohypophysis.

1. Posterior pituitary (Neurohypophysis):
   Hypothalamohypophyseal tract are nerve fibers from supraoptic and paraventricular nuclei, that send hormones to be stored and released in the poserior pituitary.
   ADH (vasopressin, mainly from supraoptic. Incraese water retention) and Oxytocin (mainly from paraventricular. Cause contraction of uterus and mamilary ducts).

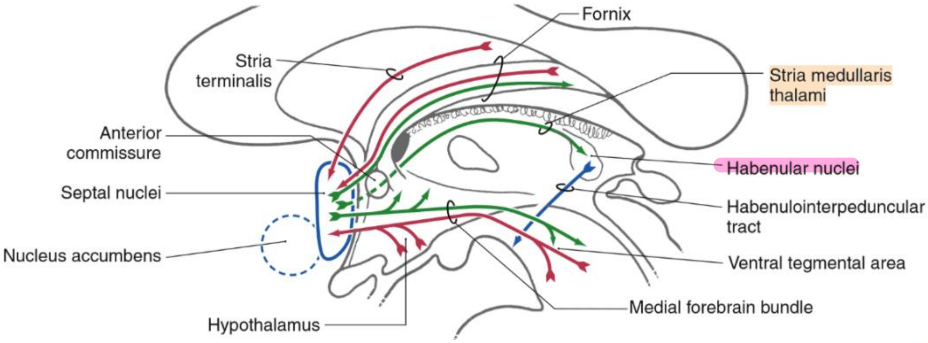
2. Anterior pituitary (Adenohypophesis):
   The Hypophyseal Portal system: blood vessels from median eminence and infundibulum. Medial part of hypothalamus Produce releasing / inhibitory hormones, transported in granules to median eminence and infundibulum, and released into sinusoids.
   Formed by Superior hypophyseal artery (branch of ICA) → divides to capillaries in median eminence → drain to long & short descending vessels → end in anterior pituitary and divide into sinusoids.

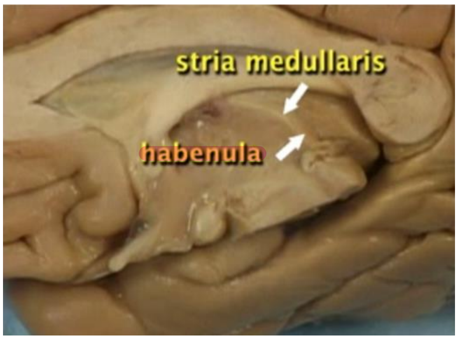
3) Epithalamus

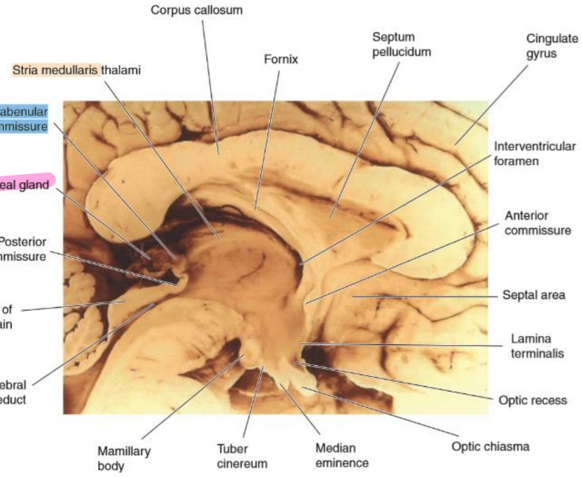
- Include the pineal gland, habenular nuclei and Stria Medullaris thalami.
- Location: posterior surface of thalamus. The habenular nuclei are above the pineal gland.

↳ connection with limbic system

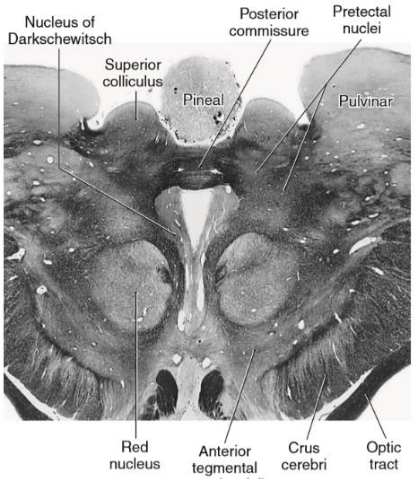
1. Habenular nuclei –
   - Small group of neurons, divided to lateral and medial nuclei. Part of limbic system. together they form the habenular trigone. The nuclei are connected by the habenular commissure.
   - Afferent fibres: stria medullaris thalami from septal nuclei (nuclei in septum pelucidum) – arch on the superior surface of thalamus to reach the habenular nuclei. Gives the main input of the habenular nuclei. Tenia thalami, the connection of choroid plexus of 3rd ventricle, runs along it.
   - Efferent fibers: Axons from habenular nuclei pass to interpeduncular fossa (through the habenulointerpeduncular tract = fasciculus retroflexus), and to tectum, thalamus and reticular formation.
   - Function: believed to be an integration site for olfactory, visual and somatic afferent fibres.
   - Habenucleuar commissure: connect the habenular nuclei on the 2 sides.

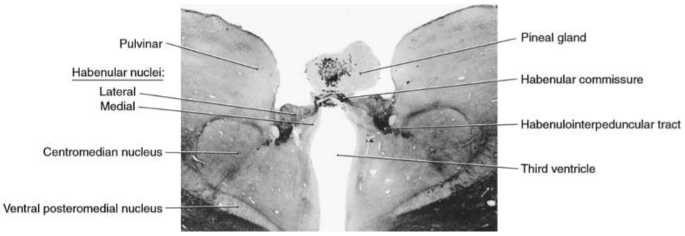

Fornix
Stria terminalis
Stria medullaris thalami
Anterior commissure
Habenular nuclei
Septal nuclei
Habenulointerpeduncular tract
Nucleus accumbens
Ventral tegmental area
Medial forebrain bundle
Hypothalamus


stria medullaris
habenula


Corpus callosum
Septum pellucidum
Cingulate gyrus
Fornix
Stria medullaris thalami
Habenular commissure
Interventricular foramen
Pineal gland
Anterior commissure
Posterior commissure
Septal area
Tectum of midbrain
Lamina terminalis
Cerebral aqueduct
Optic recess
Optic chiasma
Mamillary body
Tuber cinereum
Median eminence

2. Pineal gland –
   - Function: endocrine gland, secrete melatonin that control the circadian cycle. The hormone is secreted to the CSF, and from there it moves to the blood.
   - Location: posterior to thalamus. Between the superior colliculi.
     Above it – habenular commissure. Below it – posterior commissure.
   - Shape: Small, conical. Attached by pineal stalk to diencephalon.
   - Pineal recess: continous with the 3rd ventricle.
   - Histologicaly – The gland is divided to ill-defined lobules by CT septa from its capsule.
   - 2 cell types: pinealocytes & glial cells. NO nerve cells but adrenergic sympathetic fibres from superior cervical symapthetic ganglia enter gland.
   - Brain sand: calcified material.
   - Pineal gland has no blood-brain-barrier.
   - Nervous input: from suprachiasmatic nucleus, via tegmentum (photosensitive).

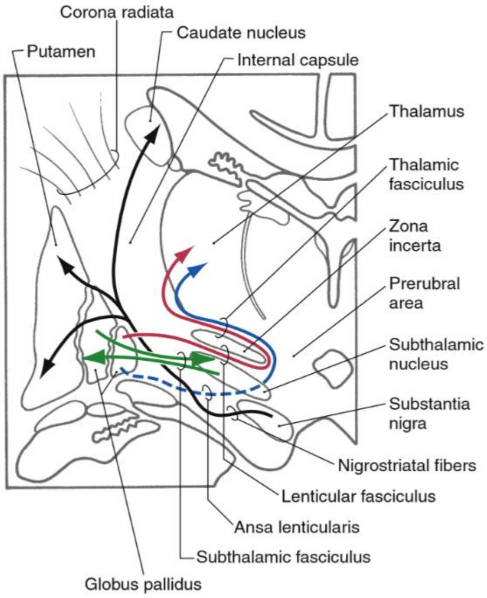

Nucleus of Darkschewitsch
Posterior commissure
Pretectal nuclei
Superior colliculus
Pineal
Pulvinar
Red nucleus
Anterior tegmental
Crus cerebri
Optic tract


Pulvinar
Habenular nuclei:
Lateral
Medial
Centromedian nucleus
Ventral posteromedial nucleus
Pineal gland
Habenular commissure
Habenulointerpeduncular tract
Third ventricle

Ansa lenticularis and fasciculus lenticularis – 2 pathways from Globus Pallidus to thalamus.
These are the two largest bundles of efferent fibers exiting the basal nuclei. They merge to form the thalamic fasciculus.

4) Subthalamus Coronal Section

- Also called ventral thalamus.
- Position: Inferior to thalamus, superior to tegmentum of midbrain, posterior to the hypothalamus.
- Structure: (you only need to show the subthalamus)
  1. Subthalamic nucleus – above the substantia nigra. Inferior to thalamus and lenticular fasciculus.
     Input: motor cortex.
     Output: substantia nigra and Globus Pallidus.
  2. Prerubral area – field H of forel. Area through which fibers pass.
     Above the red nucleus, medial to Subthalamic nucleus.
     Fibers: forel's field H1 – thalamic fasciculus.
     Forel's field H2 – lenticular fasciculus.
  3. Zona incerta – posterior. Above subthalamic nucleus.
     Function: part of the thirst regulation pathway.
     input: motor cortex and medial lamniscus.
     output: cortex, superior coliculus, pons and others.


Corona radiata
Caudate nucleus
Putamen
Internal capsule
Thalamus
Thalamic fasciculus
Zona incerta
Prerubral area
Subthalamic nucleus
Substantia nigra
Nigrostriatal fibers
Lenticular fasciculus
Ansa lenticularis
Subthalamic fasciculus
Globus pallidus

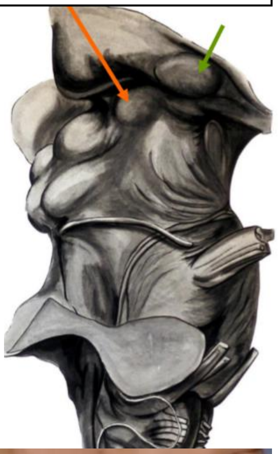
5) Methathalamus → grey matter, located inferiorly

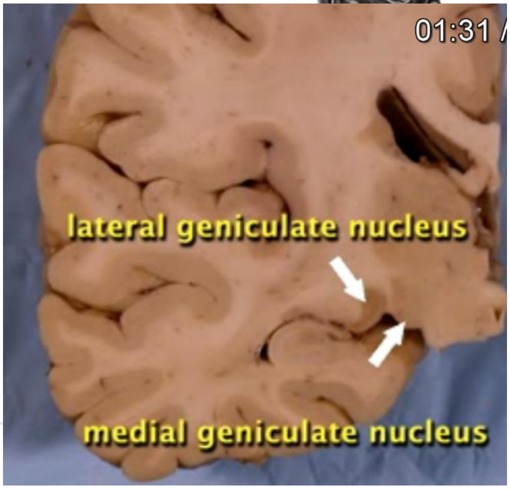
- Medial and lateral geniculate bodies. Can be considered as part of thalamus.

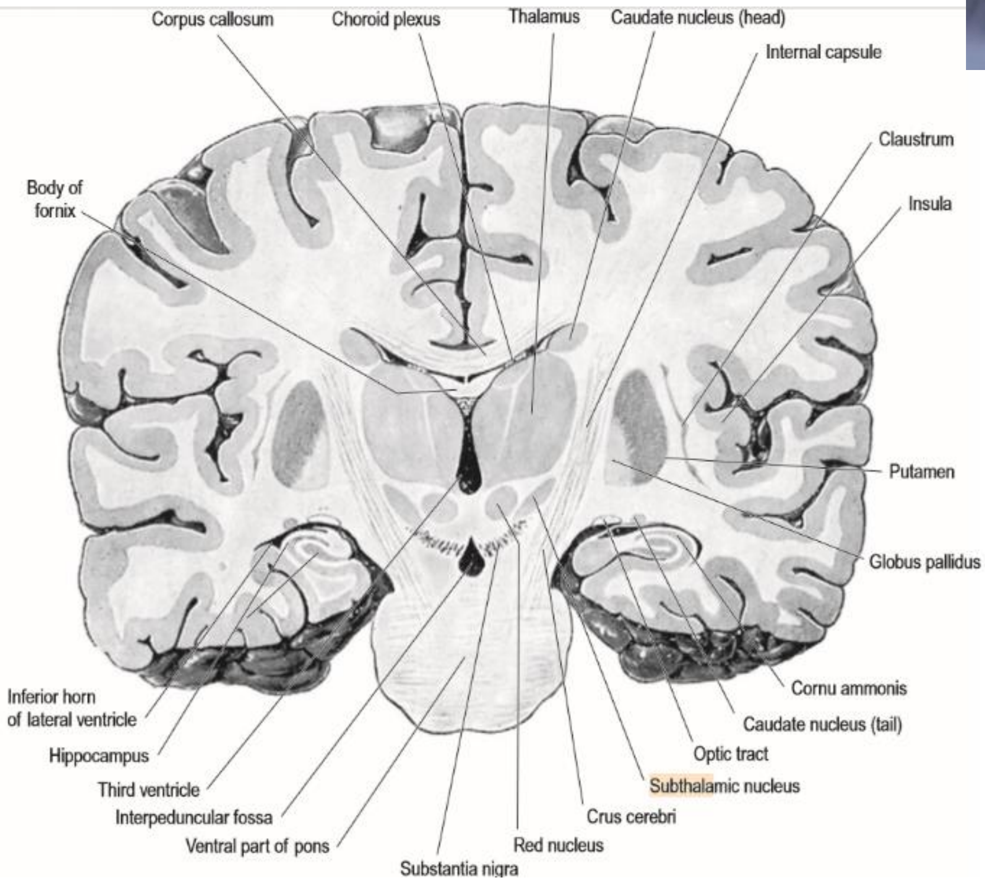
Blood supply of diencephalon:

- Supplied by small branches from the arteries making up the circle of Willis.
- Hypothalamus and subthalamus – central branches of the circle.
    - Anterior hypothalamus – anterior communicating artery and the A1.
    - Posterior hypothalamic and subthalamus – posterior communicating artery and the P1.
- Thalamus – P1 and the medial posterior choroidal artery.

Medial (orange, left) and Lateral (green) geniculate bodies




01:31
lateral geniculate nucleus
medial geniculate nucleus

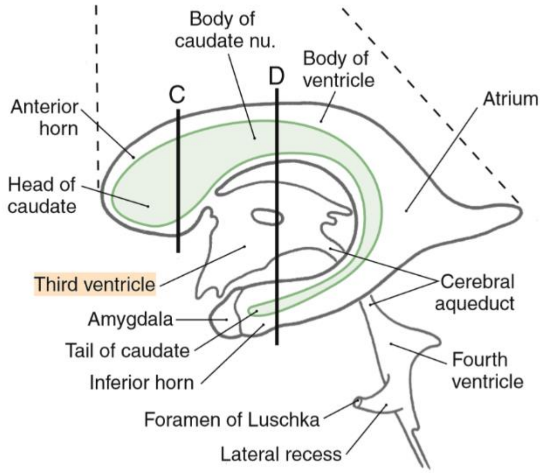

Corpus callosum
Choroid plexus
Thalamus
Caudate nucleus (head)
Internal capsule
Claustrum
Insula
Body of fornix
Putamen
Globus pallidus
Cornu ammonis
Caudate nucleus (tail)
Optic tract
Subthalamic nucleus
Crus cerebri
Red nucleus
Substantia nigra
Inferior horn of lateral ventricle
Hippocampus
Third ventricle
Interpeduncular fossa
Ventral part of pons

Subthalamus – seen at the level of Globus Pallidus, red nucleus, substantia nigra.

Notice – the interpeduncular fossa looks like a hole between the substantia nigra. Don't confuse it with the cerebral Aqueduct that should be close to the superior colliculus, and posterior + inferior to the 3rd ventricle (so they can't be on the same section).

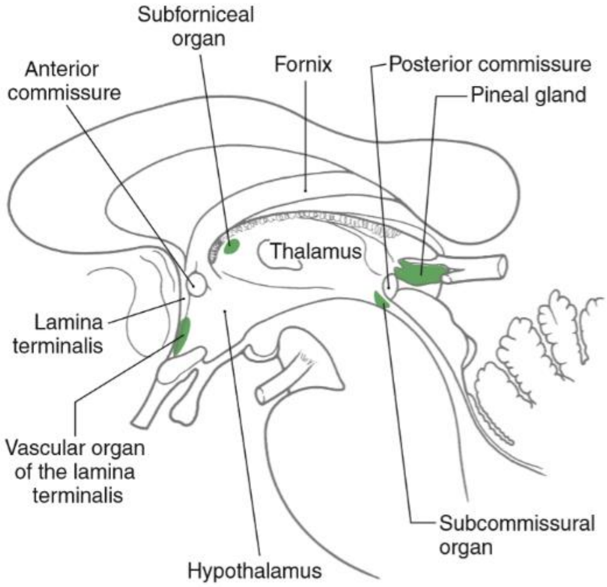
Topic 10 – Borders and walls of the third ventricle

Hain's 85, Barr's 198.


Body of caudate nu.
Body of ventricle
D
C
Anterior horn
Atrium
Head of caudate
Third ventricle
Cerebral aqueduct
Amygdala
Tail of caudate
Fourth ventricle
Inferior horn
Foramen of Luschka
Lateral recess

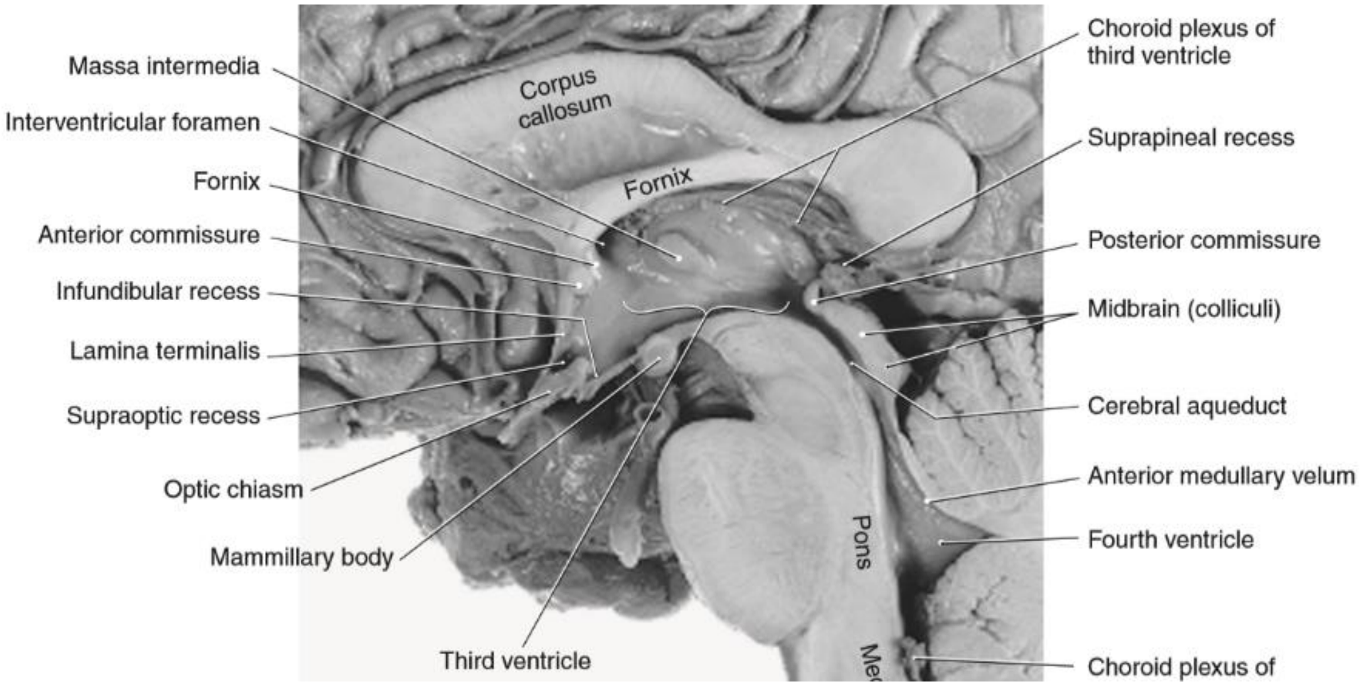
- The third ventricle is the cavity of the diencephalon.
- Shape: narrow, vertical.
- Communications:
  1. Lateral ventricle – anteriorly, Through the interventricular foramina, located between Lamina Terminalis and thalamus.
  2. Fourth ventricle – posteriorly, through the cerebral aqueduct.
- Choroid plexus: attach the thalamus by the Tenia Thalami, along the Stria Medullaris Thalami. Continues with the choroid plexus of the lateral ventricle, through the interventricular foramina. CSF enter the ventricle from the lateral ventricle, and continue into the 4th ventricle.
- Recesses: small extensions of the ventricle, named after the structure adjacent to them –
  1. Supraoptic recess – above the optic chiasm.
  2. Infundibular recess – in the infundibulum, the stalk of the pituitary. Surrounded by the diaphragm of dura.
  3. Pineal recess – in the stalk of the pineal gland, beneath the Habenula.
  4. Suprapineal recess – above the pineal gland.
- Inter-thalamic adhesion, that connects the 2 thalami, and pass through the third ventricle.
- circumventricular organs – places in the 3rd ventricle that have no blood-brain barrier. Instead, they have specialized ependymal and fenestrated capillaries, that enable these structures to sense substances in blood, as hormones, ions and toxins:
  1. Sub-fornical organ – small eminence on the medial side of the column of the fornix.
  2. Organum vasculosum – part of Lamina Terminalis.
  3. Subcommissural organ – inferior to posterior commissure.
  4. Pineal Gland.

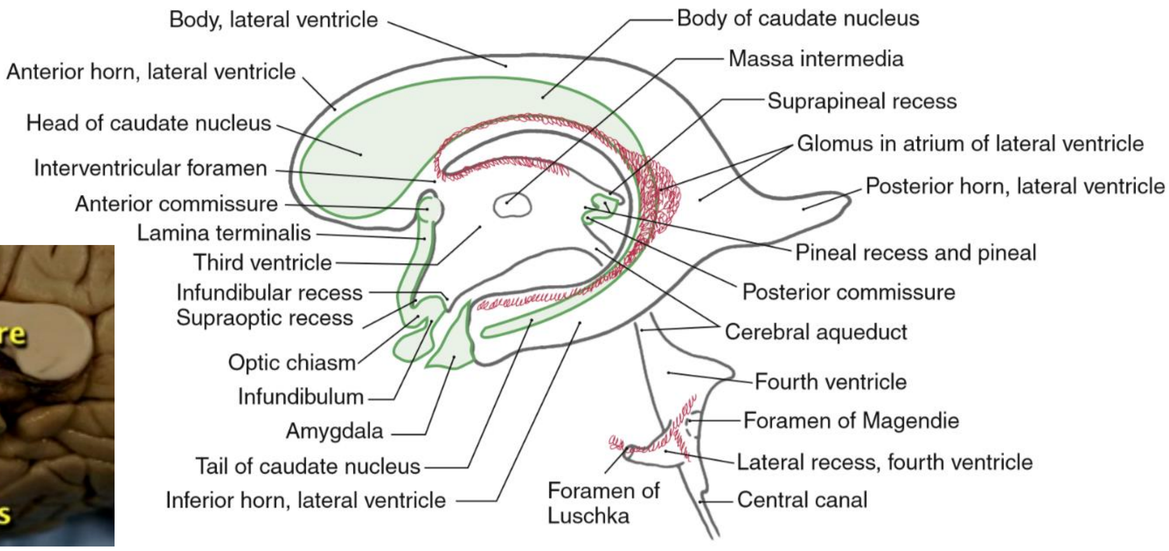
  Additional circumventricular organs in the brain:
  1. Area Postrema in the medulla – 4th ventricle.
  2. Neurohypophysis (posterior lobe of pituitary gland).

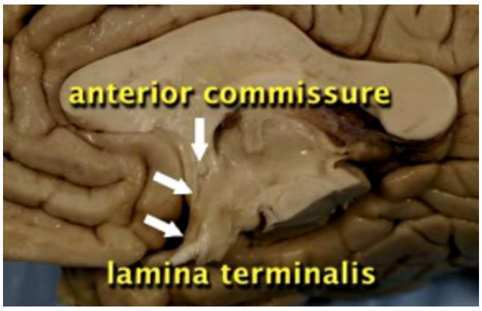

Subforniceal organ
Anterior commissure
Fornix
Posterior commissure
Pineal gland
Thalamus
Lamina terminalis
Vascular organ of the lamina terminalis
Subcommissural organ
Hypothalamus

Borders:

- Superior: Tenia Thalami, from which the choroid plexus is suspended. The fornix is superior to the choroid plexus.
- Inferior: from anterior – optic chiasm, infundibulum, mammillary body, midbrain roof, cerebral aqueduct and posterior commissure.
- Anterior: anterior commissure and the Lamina Terminalis – thin membrane that extends from the anterior commissure anteriorly, to the optic chiasm.
  additional: not exactly the borders but found anteriorly – Columns of fornix, posterior to the anterior commissure, and anterior to the interventricular foramen.
- Posterior: from inferior – posterior commissure, pineal recess and habenular commissure.
- Lateral: thalamus, and hypothalamus inferior-anterior to it. Both are separated by the Hypothalamic sulcus. It runs from the interventricular foramen to the cerebral aqueduct.
  Stria Medullaris thalami (fibers between septal nuclei and habenular nuclei) is on the superior part of the thalamus.


Massa intermedia
Interventricular foramen
Fornix
Anterior commissure
Infundibular recess
Lamina terminalis
Supraoptic recess
Optic chiasm
Mammillary body
Third ventricle
Corpus callosum
Fornix
Pons
Choroid plexus of third ventricle
Suprapineal recess
Posterior commissure
Midbrain (colliculi)
Cerebral aqueduct
Anterior medullary velum
Fourth ventricle
Choroid plexus of


Body, lateral ventricle
Anterior horn, lateral ventricle
Head of caudate nucleus
Interventricular foramen
Anterior commissure
Lamina terminalis
Third ventricle
Infundibular recess
Supraoptic recess
Optic chiasm
Infundibulum
Amygdala
Tail of caudate nucleus
Inferior horn, lateral ventricle
Foramen of Luschka
Body of caudate nucleus
Massa intermedia
Suprapineal recess
Glomus in atrium of lateral ventricle
Posterior horn, lateral ventricle
Pineal recess and pineal
Posterior commissure
Cerebral aqueduct
Fourth ventricle
Foramen of Magendie
Lateral recess, fourth ventricle
Central canal


anterior commissure
lamina terminalis

Topic 11 – Demonstration of the structures around and within the cavernous sinus (cranial nerves, sinuses, blood vessels).

Barr's 390, Hain's 119, 391.

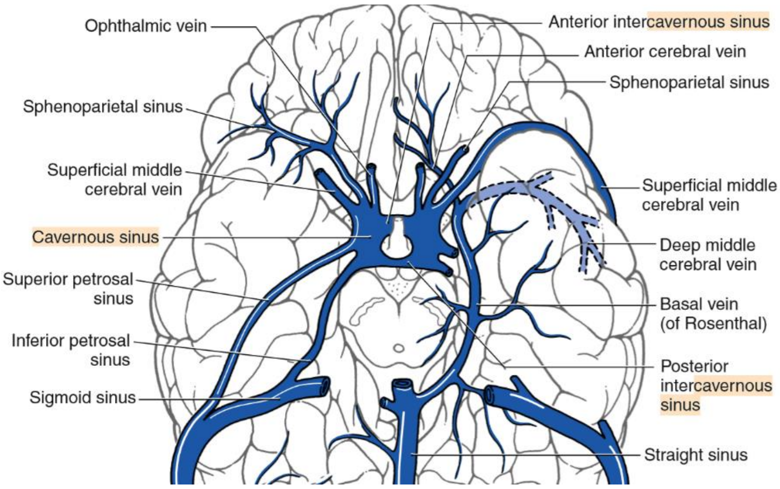
The Cavernous Sinus:

- There are 2 cavernous sinuses, one on each side the of the body of sphenoid bone, surrounding the Sella Turcica and the Diaphragm Sellae.
- The sinuses of each side communicate through the Anterior and Posterior **Intercavernous sinuses**.
- The sinuses are extradural, Lined with very thin endothelium.

Vessels related to the Cavernous Sinus:

1. Veins that drain into the cavernous sinus:

- ophthalmic vein – communicate with angular vein, thus enables blood from the face to enter the cavernous sinus and into the brain. Enters through the superior orbital fissure.
- Superficial middle cerebral vein – from the lateral surface of hemisphere.

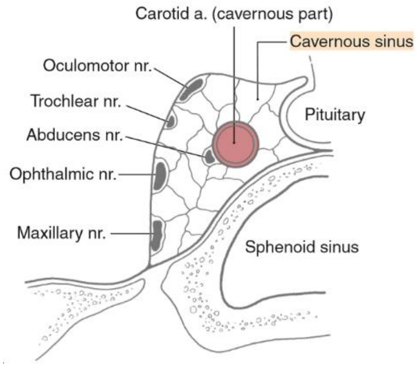

Ophthalmic vein
Anterior intercavernous sinus
Anterior cerebral vein
Sphenoparietal sinus
Sphenoparietal sinus
Superficial middle cerebral vein
Superficial middle cerebral vein
Cavernous sinus
Deep middle cerebral vein
Superior petrosal sinus
Basal vein (of Rosenthal)
Inferior petrosal sinus
Posterior intercavernous sinus
Sigmoid sinus
Straight sinus

2. The Cavernous sinus drains into the following sinuses:

- Superior petrosal sinuses – along the attachment of Tentorium Cerebelli to the superior part of petrous bone. Drain to transverse sinus.
- Inferior petrosal sinuses – pass in a groove between petrous bone and basilar part of the occipital bone. Drain into the Internal jugular vein.
- Basilar plexus – anterior to the brainstem.

3. artery that pass through it:

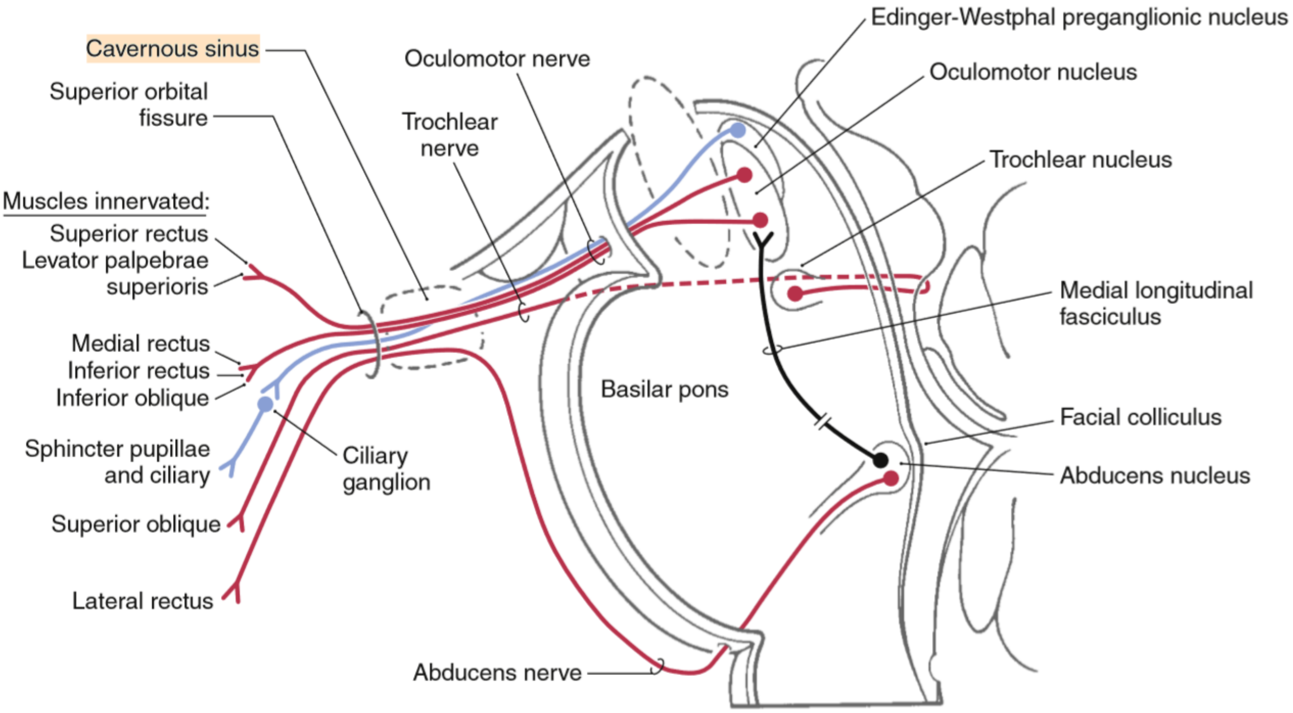
- Internal carotid artery (ICA) – its cavernous part passes in the sinus, and gives rise to the Inferior Hypophyseal and Meningeal arteries. The preceding part of ICA is the petrous part, and the following part is the cerebral part.


Carotid a. (cavernous part)
Cavernous sinus
Oculomotor nr.
Trochlear nr.
Abducens nr.
Ophthalmic nr.
Maxillary nr.
Pituitary
Sphenoid sinus

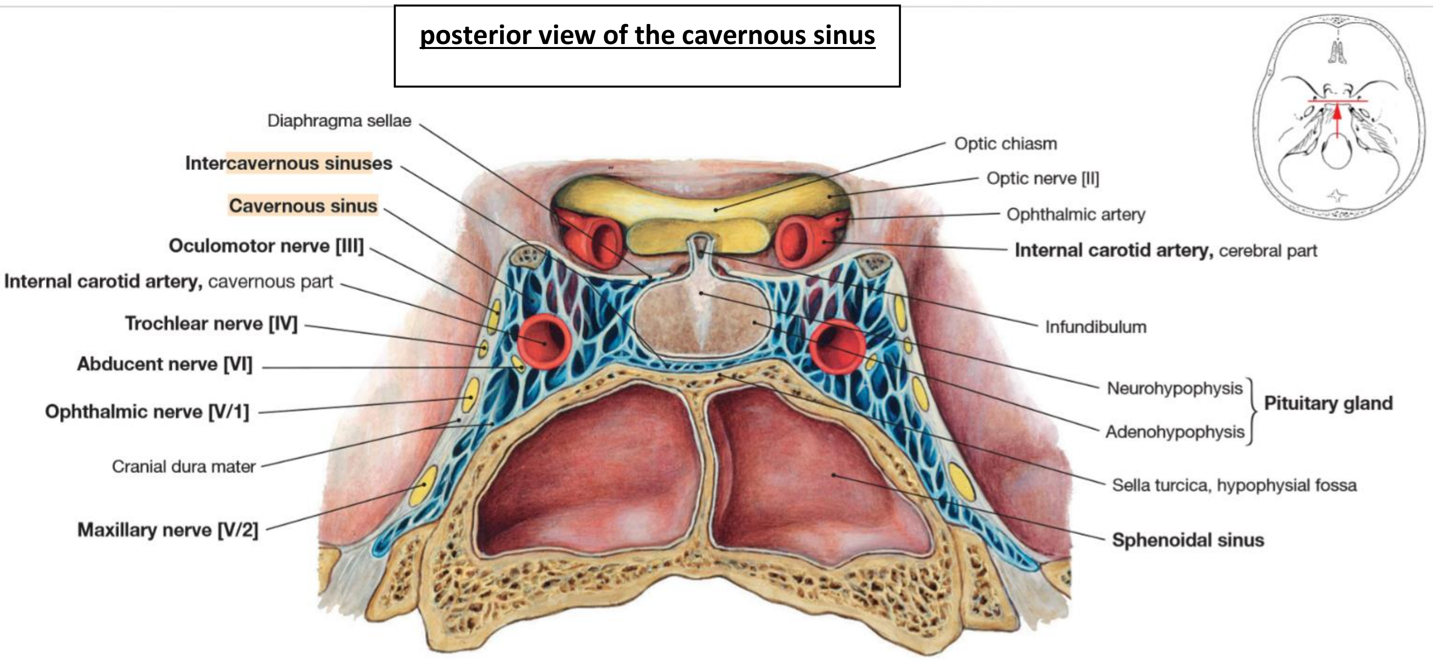
Cranial nerves that pass in the cavernous sinus:

These nerves are internal to the dura surrounding the sinus, and external to the sinus endothelial lining. from superior to inferior:

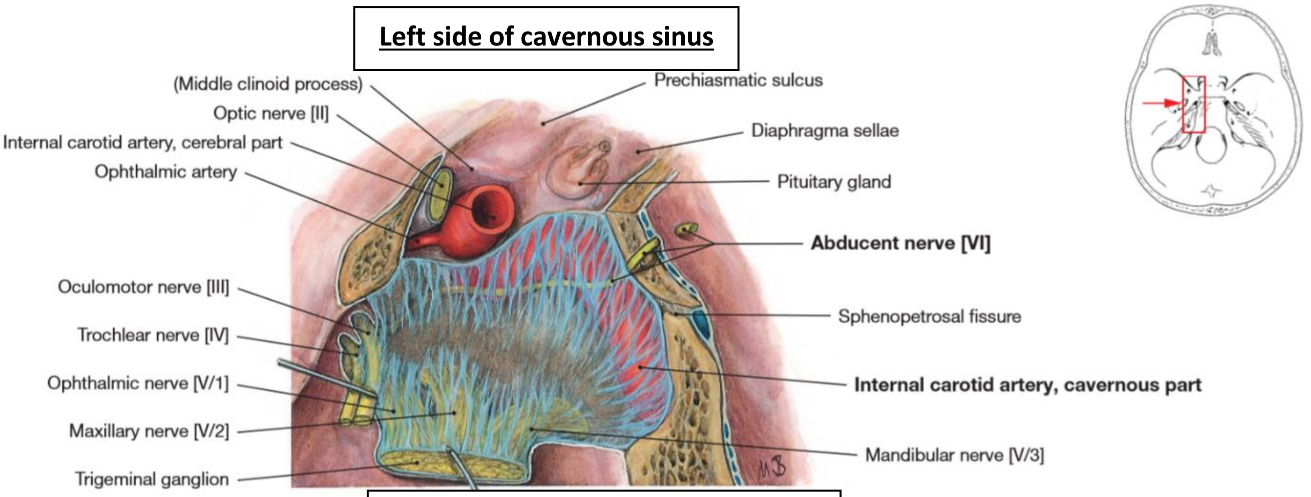
1. Oculomotor nerve – at the lateral wall of the sinus.
2. Trochlear nerve – at the lateral wall of the sinus.
3. Abducent nerve – in the middle of the sinus, next to ICA.
4. Trigeminal nerve – ophthalmic and maxillary branches. at the lateral wall of the sinus.
5. Sympathetic supply to the orbit – from superior cervical sympathetic ganglion. Enter cranium on ICA and travel in the sinus with C.N. 6 and then with C.N. 3 and 5.


Cavernous sinus
Superior orbital fissure
Muscles innervated:
Superior rectus
Levator palpebrae superioris
Medial rectus
Inferior rectus
Inferior oblique
Sphincter pupillae and ciliary
Superior oblique
Lateral rectus
Oculomotor nerve
Trochlear nerve
Ciliary ganglion
Basilar pons
Abducens nerve
Edinger-Westphal preganglionic nucleus
Oculomotor nucleus
Trochlear nucleus
Medial longitudinal fasciculus
Facial colliculus
Abducens nucleus

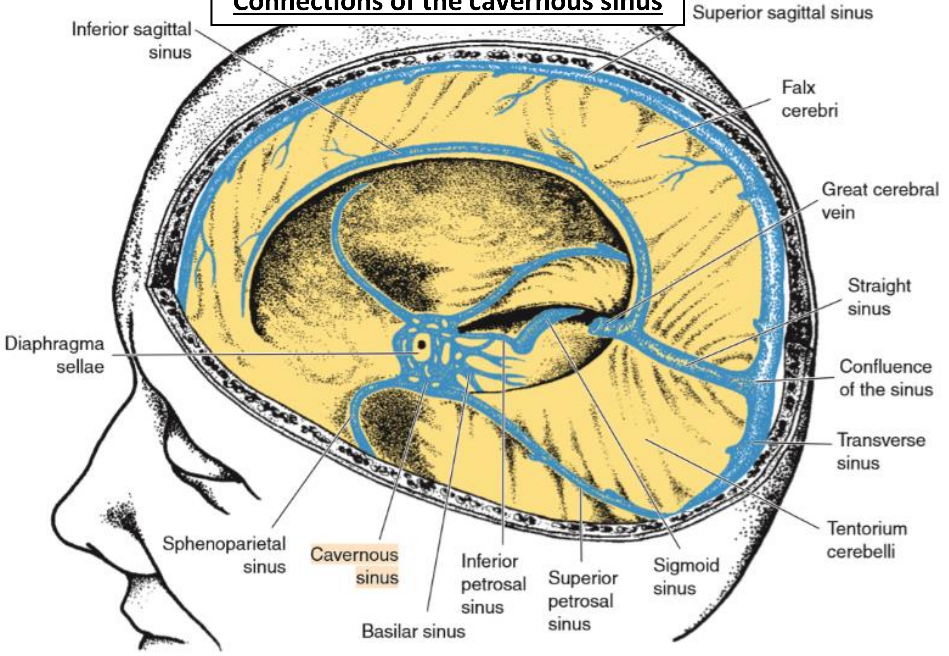
posterior view of the cavernous sinus


Diaphragma sellae
Intercavernous sinuses
Cavernous sinus
Oculomotor nerve [III]
Internal carotid artery, cavernous part
Trochlear nerve [IV]
Abducent nerve [VI]
Ophthalmic nerve [V/1]
Cranial dura mater
Maxillary nerve [V/2]
Optic chiasm
Optic nerve [II]
Ophthalmic artery
Internal carotid artery, cerebral part
Infundibulum
Neurohypophysis
Adenohypophysis
Pituitary gland
Sella turcica, hypophysial fossa
Sphenoidal sinus

Left side of cavernous sinus


(Middle clinoid process)
Optic nerve [II]
Internal carotid artery, cerebral part
Ophthalmic artery
Oculomotor nerve [III]
Trochlear nerve [IV]
Ophthalmic nerve [V/1]
Maxillary nerve [V/2]
Trigeminal ganglion
Prechiasmatic sulcus
Diaphragma sellae
Pituitary gland
Abducent nerve [VI]
Sphenopetrosal fissure
Internal carotid artery, cavernous part
Mandibular nerve [V/3]

Connections of the cavernous sinus

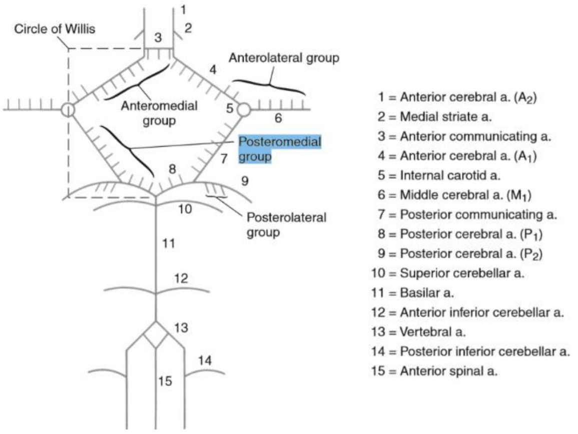

Superior sagittal sinus
Inferior sagittal sinus
Falx cerebri
Great cerebral vein
Straight sinus
Confluence of the sinus
Transverse sinus
Tentorium cerebelli
Diaphragma sellae
Sphenoparietal sinus
Cavernous sinus
Basilar sinus
Inferior petrosal sinus
Superior petrosal sinus
Sigmoid sinus

Topic 12 – Structures around the interpeduncular fossa

- Interpeduncular fossa is the space between the cerebral peduncles of the midbrain.
- The cerebral peduncles, also called crus cerebri, are at the basis part of the midbrain, conveying **descending** fibers – corticospinal (to spinal cord) and corticonuclear (to nuclei in the brain stem).
- Interpeduncular Cistern – the subarachnoid space of this region.
- Interpeduncular Nucleus – found beneath the floor of the interpeduncular fossa.

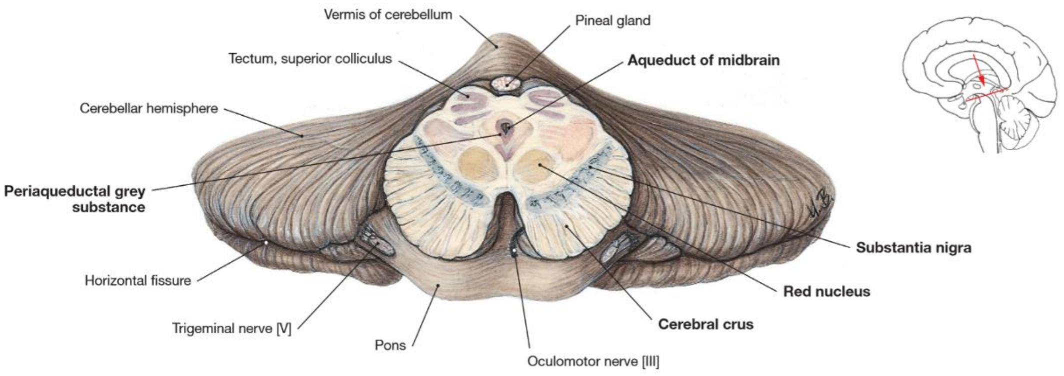
Structures in the interpeduncular fossa:

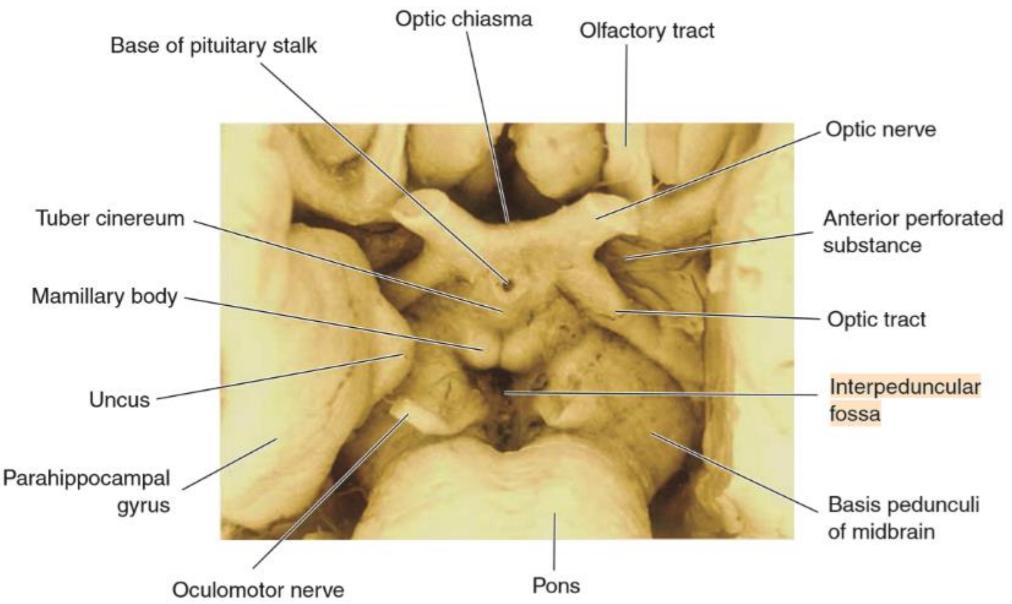
- Posterior perforated substance – dotted area, made by small blood vessels that penetrate into midbrain.
  These are branches of the central arteries of the Circle of Willis. They originate from P1 and the posterior communicating artery, that are part of the posteromedial group of the central arteries.
- Oculomotor nerves – exit the midbrain through the fossa, and passes between the posterior cerebral and superior cerebellar arteries.
- Upper part of the basilar artery – including its bifurcation and proximal branches. Gives the posterior cerebellar arteries.
- Part of basal vein.

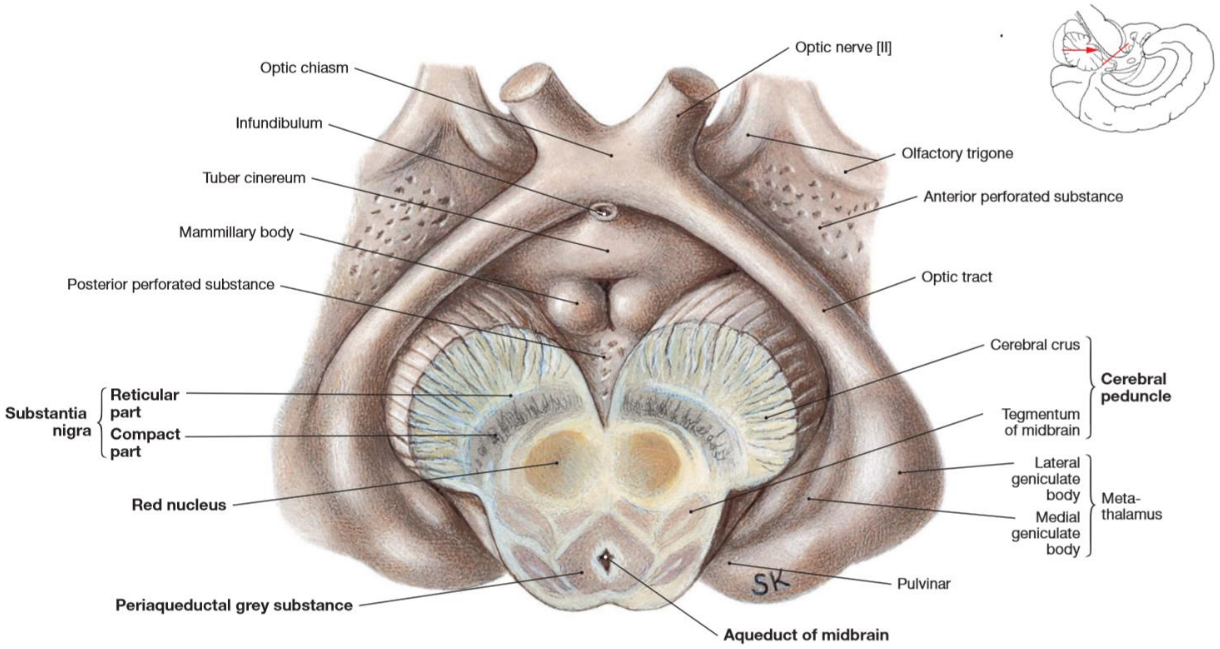

Circle of Willis
Anterolateral group
Anteromedial group
Posteromedial group
Posterolateral group
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
1 = Anterior cerebral a. (A2)
2 = Medial striate a.
3 = Anterior communicating a.
4 = Anterior cerebral a. (A1)
5 = Internal carotid a.
6 = Middle cerebral a. (M1)
7 = Posterior communicating a.
8 = Posterior cerebral a. (P1)
9 = Posterior cerebral a. (P2)
10 = Superior cerebellar a.
11 = Basilar a.
12 = Anterior inferior cerebellar a.
13 = Vertebral a.
14 = Posterior inferior cerebellar a.
15 = Anterior spinal a.

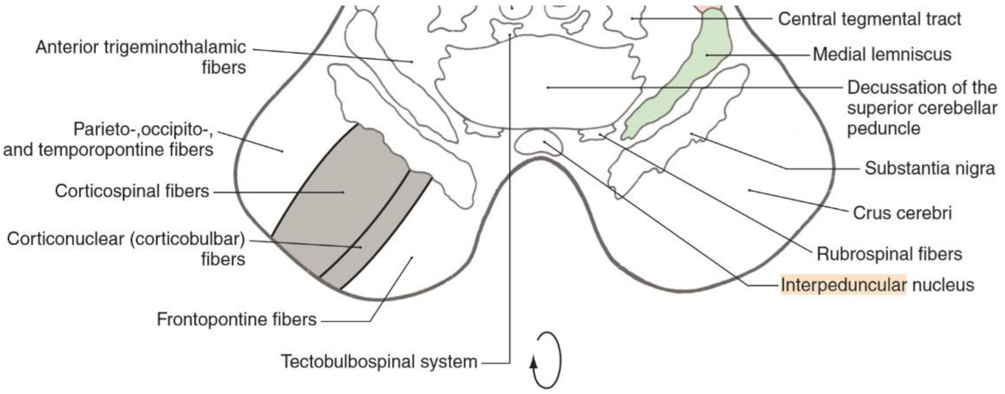
Structures around the interpeduncular fossa:

- Anterior: Mammillary body, superior cerebellar artery and posterior cerebral artery.
- Inferior: Basis of pons.
- Laterally: uncus of parahypocampal gyrus.
- Inside the midbrain:
  1. Substantia nigra.
  2. Tracts of crus cerebri.
  3. Interpeduncular nucleus.


Vermis of cerebellum
Pineal gland
Tectum, superior colliculus
Aqueduct of midbrain
Cerebellar hemisphere
Periaqueductal grey substance
Horizontal fissure
Trigeminal nerve [V]
Pons
Oculomotor nerve [III]
Cerebral crus
Red nucleus
Substantia nigra

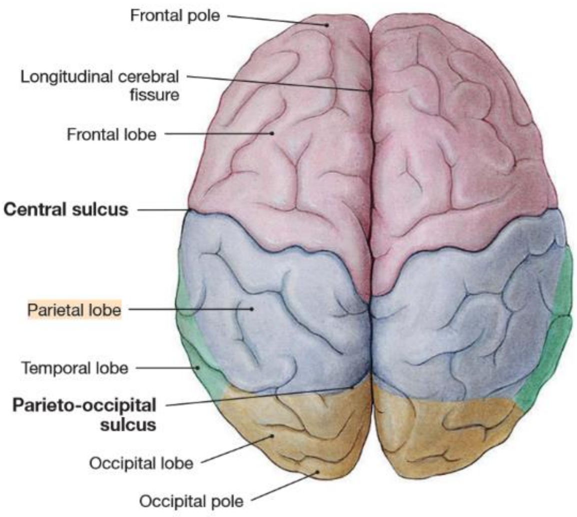

Optic chiasma
Base of pituitary stalk
Olfactory tract
Optic nerve
Tuber cinereum
Anterior perforated substance
Mamillary body
Optic tract
Uncus
Interpeduncular fossa
Parahippocampal gyrus
Basis pedunculi of midbrain
Oculomotor nerve
Pons

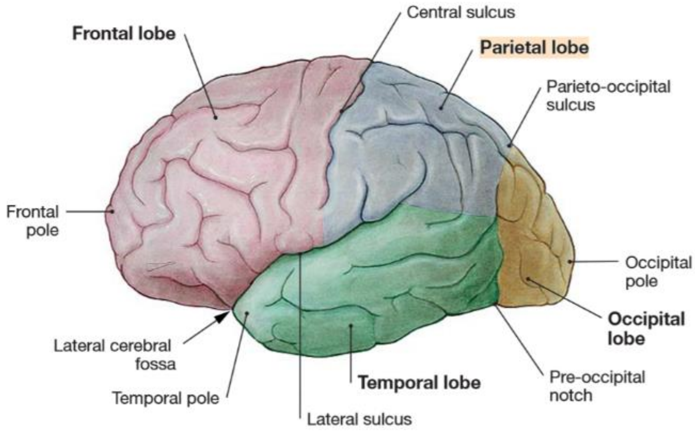

Optic nerve [II]
Optic chiasm
Infundibulum
Olfactory trigone
Tuber cinereum
Anterior perforated substance
Mammillary body
Optic tract
Posterior perforated substance
Cerebral crus
Cerebral peduncle
Tegmentum of midbrain
Substantia nigra
Reticular part
Compact part
Lateral geniculate body
Meta-thalamus
Medial geniculate body
Red nucleus
SK
Pulvinar
Periaqueductal grey substance
Aqueduct of midbrain

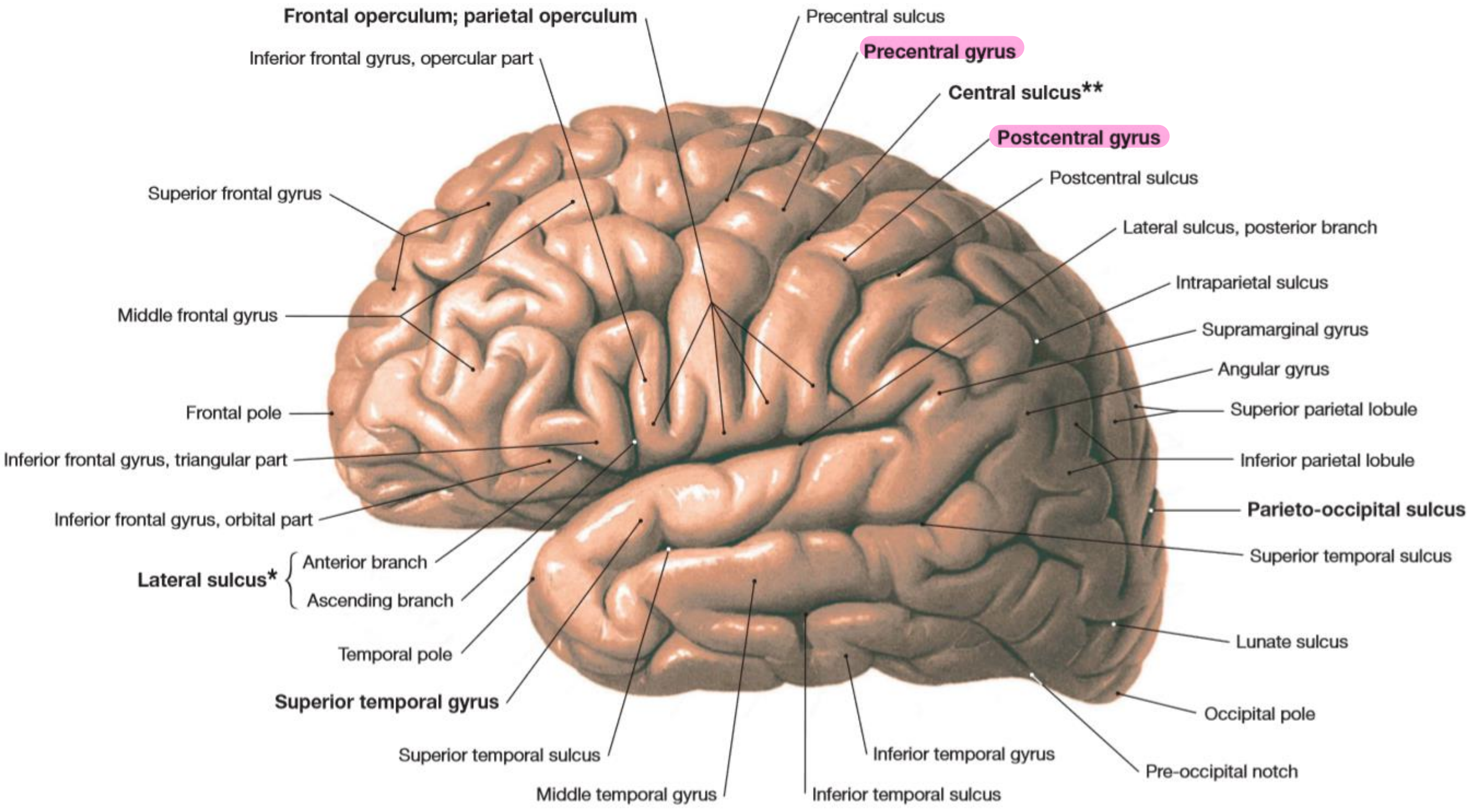

Central tegmental tract
Anterior trigeminothalamic fibers
Medial lemniscus
Decussation of the superior cerebellar peduncle
Parieto-,occipito-, and temporopontine fibers
Substantia nigra
Corticospinal fibers
Crus cerebri
Corticonuclear (corticobulbar) fibers
Rubrospinal fibers
Interpeduncular nucleus
Frontopontine fibers
Tectobulbospinal system

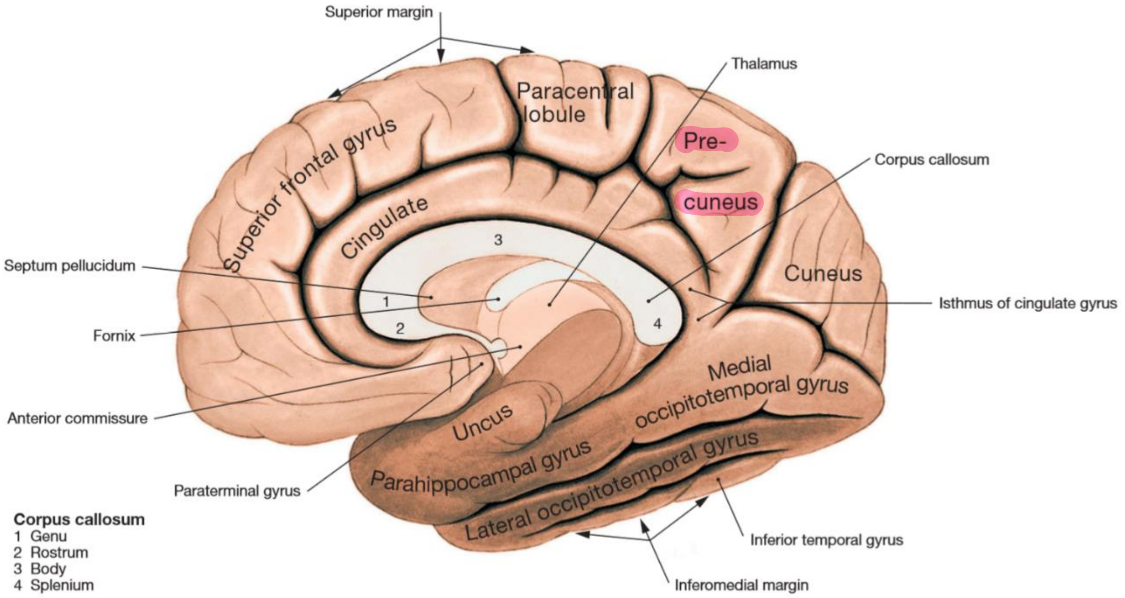
**Intro and Pictures of the cortex for topics 13-16

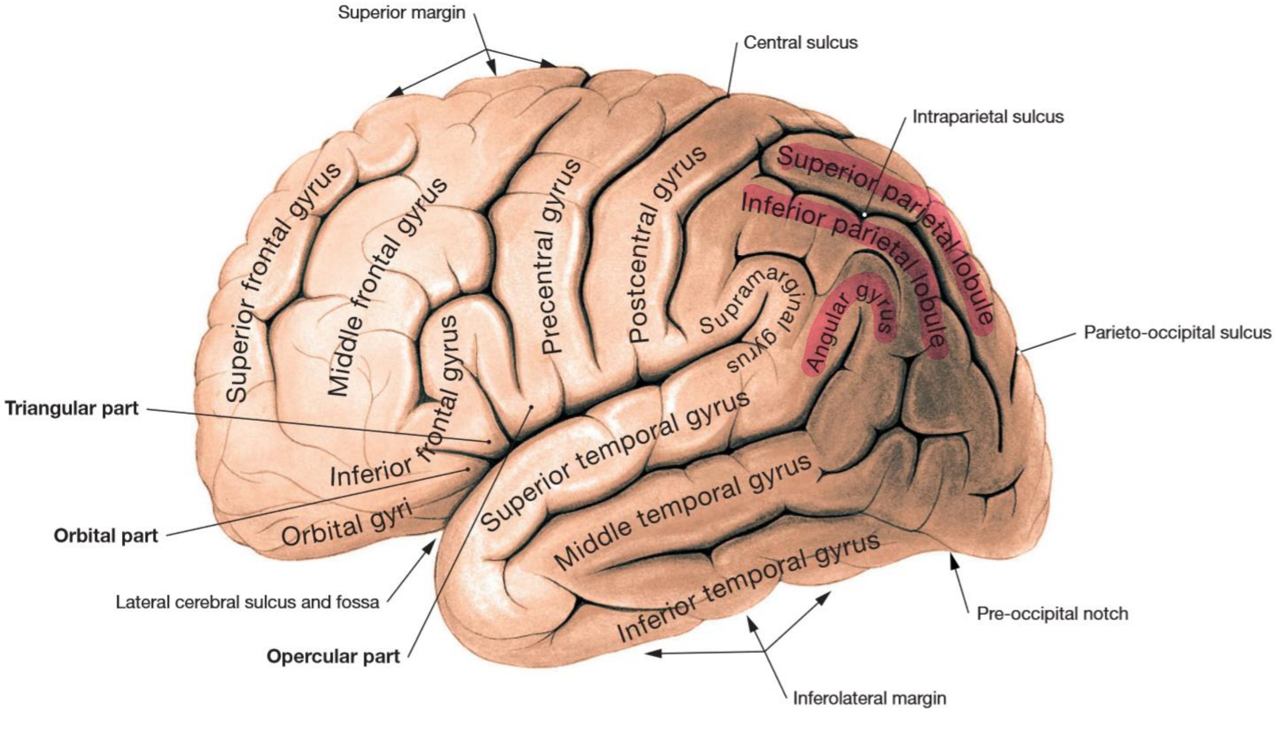
- Gyrus – gyri in plural. It is a ridge on the cortex. Made of neuron's cell bodies. For that reason, it is called 'grey matter'. The gyri are easy to distinct from one another.
- Sulcus – sulci in plural. Separates the gyri.
- Longitudinal cerebral fissure – separates the 2 hemispheres.
- The Central Sulcus is useful for orientation. It is the deepest, gets almost into the lateral sulcus (but ends before it), and extends into the medial surface of hemisphere.

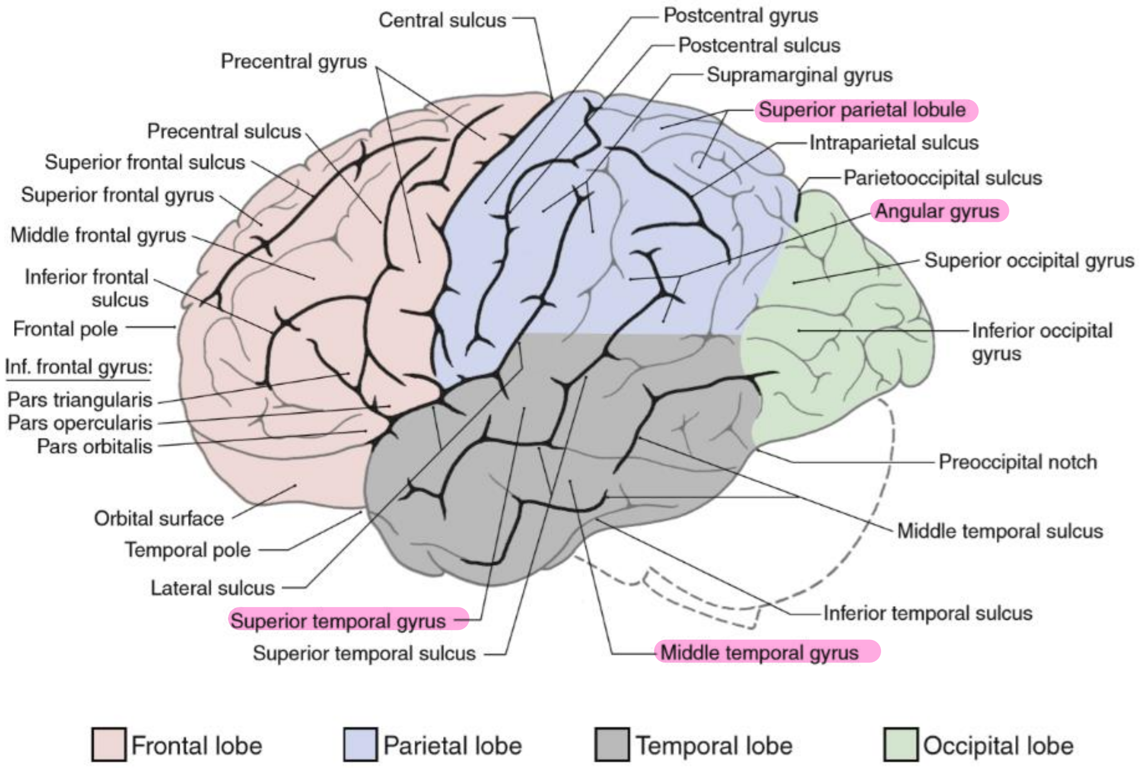

Frontal pole
Longitudinal cerebral fissure
Frontal lobe
Central sulcus
Parietal lobe
Temporal lobe
Parieto-occipital sulcus
Occipital lobe
Occipital pole

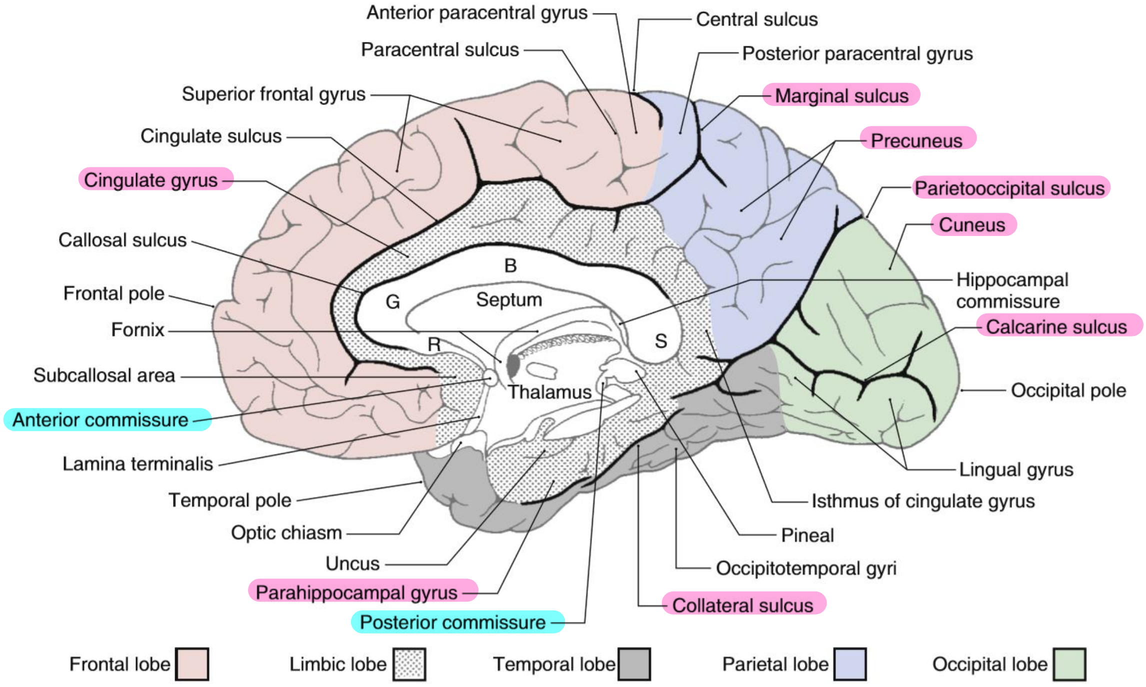

Frontal lobe
Central sulcus
Parietal lobe
Parieto-occipital sulcus
Frontal pole
Occipital pole
Occipital lobe
Lateral cerebral fossa
Temporal pole
Temporal lobe
Lateral sulcus
Pre-occipital notch

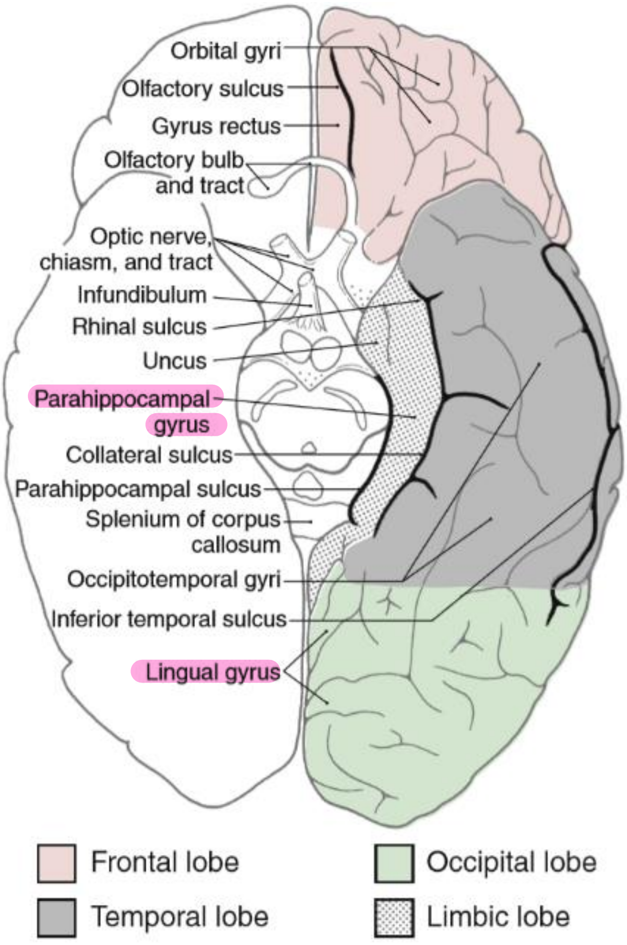

Frontal operculum; parietal operculum
Inferior frontal gyrus, opercular part
Precentral sulcus
Precentral gyrus
Central sulcus**
Postcentral gyrus
Postcentral sulcus
Superior frontal gyrus
Lateral sulcus, posterior branch
Intraparietal sulcus
Middle frontal gyrus
Supramarginal gyrus
Angular gyrus
Frontal pole
Superior parietal lobule
Inferior frontal gyrus, triangular part
Inferior parietal lobule
Inferior frontal gyrus, orbital part
Parieto-occipital sulcus
Lateral sulcus*
Anterior branch
Ascending branch
Superior temporal sulcus
Temporal pole
Lunate sulcus
Superior temporal gyrus
Occipital pole
Superior temporal sulcus
Inferior temporal gyrus
Pre-occipital notch
Middle temporal gyrus
Inferior temporal sulcus


Superior margin
Thalamus
Paracentral lobule
Pre-
cuneus
Corpus callosum
Superior frontal gyrus
Cingulate
3
Septum pellucidum
1
Cuneus
Isthmus of cingulate gyrus
Fornix
2
4
Medial occipitotemporal gyrus
Anterior commissure
Uncus
Parahippocampal gyrus
Lateral occipitotemporal gyrus
Paraterminal gyrus
Inferior temporal gyrus
Corpus callosum
1 Genu
2 Rostrum
3 Body
4 Splenium
Inferomedial margin


Superior margin
Central sulcus
Intraparietal sulcus
Superior parietal lobule
Inferior parietal lobule
Superior frontal gyrus
Middle frontal gyrus
Precentral gyrus
Postcentral gyrus
Supramarginal gyrus
Angular gyrus
Parieto-occipital sulcus
Inferior frontal gyrus
Triangular part
Superior temporal gyrus
Orbital part
Orbital gyri
Middle temporal gyrus
Inferior temporal gyrus
Lateral cerebral sulcus and fossa
Pre-occipital notch
Opercular part
Inferolateral margin


Central sulcus
Precentral gyrus
Precentral sulcus
Superior frontal sulcus
Superior frontal gyrus
Middle frontal gyrus
Inferior frontal
sulcus
Frontal pole
Inf. frontal gyrus:
Pars triangularis
Pars opercularis
Pars orbitalis
Orbital surface
Temporal pole
Lateral sulcus
Superior temporal gyrus
Superior temporal sulcus
Postcentral gyrus
Postcentral sulcus
Supramarginal gyrus
Superior parietal lobule
Intraparietal sulcus
Parietooccipital sulcus
Angular gyrus
Superior occipital gyrus
Inferior occipital
gyrus
Preoccipital notch
Middle temporal sulcus
Inferior temporal sulcus
Middle temporal gyrus
Frontal lobe
Parietal lobe
Temporal lobe
Occipital lobe


Anterior paracentral gyrus
Paracentral sulcus
Superior frontal gyrus
Cingulate sulcus
Cingulate gyrus
Callosal sulcus
Frontal pole
Fornix
Subcallosal area
Anterior commissure
Lamina terminalis
Temporal pole
Optic chiasm
Uncus
Parahippocampal gyrus
Posterior commissure
Central sulcus
Posterior paracentral gyrus
Marginal sulcus
Precuneus
Parietooccipital sulcus
Cuneus
Hippocampal
commissure
Calcarine sulcus
Occipital pole
Lingual gyrus
Isthmus of cingulate gyrus
Pineal
Occipitotemporal gyri
Collateral sulcus
B
G
Septum
R
S
Thalamus
Frontal lobe
Limbic lobe
Temporal lobe
Parietal lobe
Occipital lobe

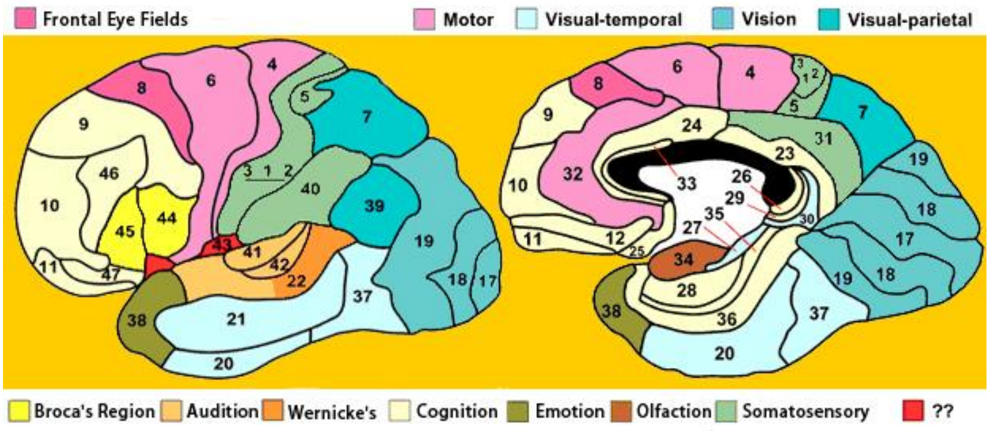

Orbital gyri
Olfactory sulcus
Gyrus rectus
Olfactory bulb and tract
Optic nerve, chiasm, and tract
Infundibulum
Rhinal sulcus
Uncus
Parahippocampal gyrus
Collateral sulcus
Parahippocampal sulcus
Splenium of corpus callosum
Occipitotemporal gyri
Inferior temporal sulcus
Lingual gyrus
Frontal lobe
Temporal lobe
Occipital lobe
Limbic lobe

Brodmann areas from the lecture:

- Brodmann 4: primary motor center; precentral gyrus.
- Brodmann 3,1,2: primary somatosensory center; postcentral gyrus.
- Brodmann 41, 42: primary auditory center; superior temporal gyrus (Heschl gyrus).
- Brodmann 17 – primary, 18 – secondary, 19 – tertiary visual centers: Occipital lobe.
- Brodmann 44, 45 (Broca area): motor speech center. Opercular and triangular parts of inferior frontalis gyrus. In the dominant hemisphere!
- Brodmann 22, 39, 40: (Wernicke area) sensory speech area; Caudal part of superior temporal Gyrus, Supramarginal gyrus and angular gyrus. In the dominant hemisphere! Usually left.

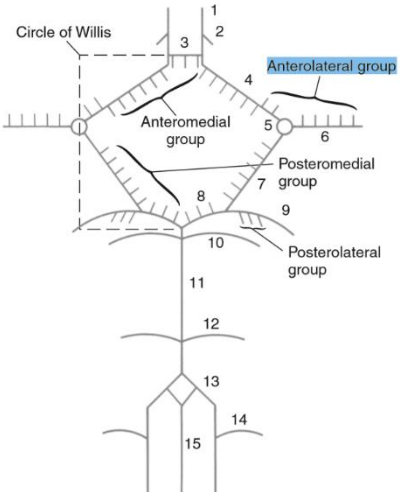
Notice – association cortex is any part of cortex that is not primary cortex of something.

e.g. – association visual cortex, premotor cortex.


Frontal Eye Fields
Motor
Visual-temporal
Vision
Visual-parietal
Broca's Region
Audition
Wernicke's
Cognition
Emotion
Olfaction
Somatosensory
??

Topic 13 – Gyri (with their corresponding Brodmann area numbers) and sulci of the frontal lobe.

Hain's 213, Barr's 216.


Circle of Willis
1
2
3
Anterolateral group
4
Anteromedial group
5
6
Posteromedial group
7
8
9
10
Posterolateral group
11
12
13
14
15

Associated with the frontal lobe:

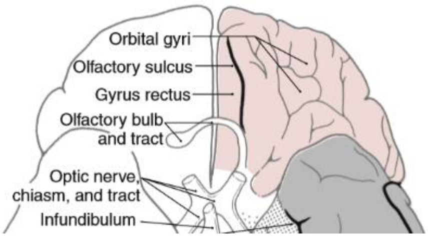
- Covered by the frontal bone.
- Anterior perforated substance – on the inferior surface. It is a dotted area, made by small blood vessels that penetrate into the brain. These vessels are part of the anterolateral group of central branches of circle of Willis. They arise from M1 and A1.
- The olfactory tract and olfactory striae, and cells of anterior perforated substance, are associated with the limbic system.

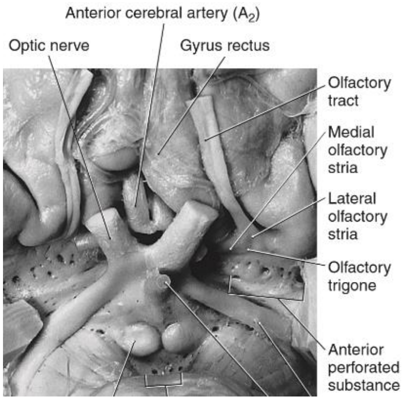
Borders:

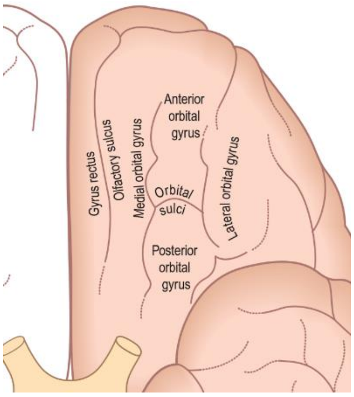
- Anterior: frontal pole.
- Posterior: central sulcus.
- Inferior: lateral sulcus.
- Medial surface: the cingulate sulcus separates it from the limbic lobe.

Gyri and sulci:

- Precentral gyrus – anterior to central sulcus. continues medially with anterior paracentral gyrus, part of the paracentral lobule on the medial side of hemisphere.
- Precentral sulcus – separate the precentral gyrus from the superior, middle and inferior frontal gyri.
- Superior and inferior frontal sulci – separate the Superior, Middle and Inferior frontal gyri.
- Superior frontal gyrus – folds into the medial part of hemisphere.
- Middle frontal gyrus.
- Inferior frontal gyrus – divided to opercular part (covers the insular lobe), triangular part (has triangle shape), and orbital part (close to the inferior surface).
- On the inferior surface – Strait gyrus, Olfactory sulcus and Orbital gyri.
- Orbital gyri – H shape sulci divide it to anterior, posterior, medial and lateral orbital gyri. Separated from each other by the orbital sulci.
- Olfactory sulcus – Olfactory bulb (anterior) and tract (posterior) are found in it. The olfactory tract bifurcates into medial and lateral striae, to form the olfactory trigone.

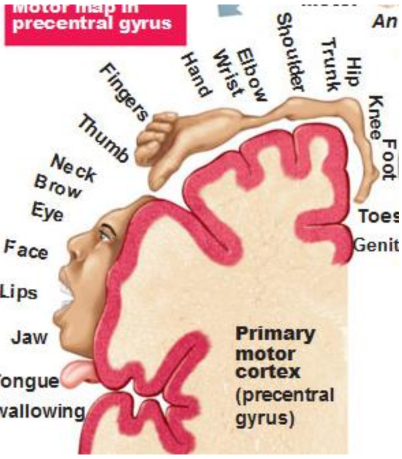

Orbital gyri
Olfactory sulcus
Gyrus rectus
Olfactory bulb and tract
Optic nerve, chiasm, and tract
Infundibulum


Anterior cerebral artery (A_2)
Optic nerve
Gyrus rectus
Olfactory tract
Medial olfactory stria
Lateral olfactory stria
Olfactory trigone
Anterior perforated substance


Gyrus rectus
Olfactory sulcus
Medial orbital gyrus
Anterior orbital gyrus
Orbital sulci
Lateral orbital gyrus
Posterior orbital gyrus

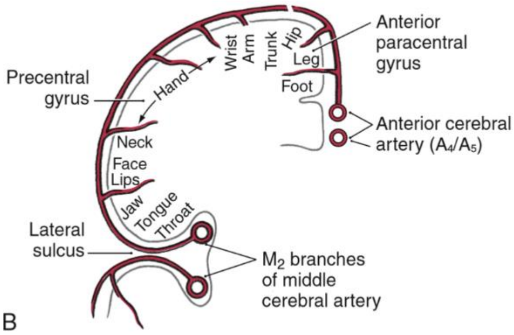
Brodmann areas:

- Primary somatomotor cortex – Brodmann area 4. made by precentral and superior frontal gyrus. Responsible for control of body parts. The body is somatotopically arranged on it (homunculus):
  - lateral third of precentral gyrus – face.
  - middle third of precentral gyrus – hand and upper limb.
  - medial third of precentral gyrus – trunk.
  - between precentral and anterior paracentral gyri (medial side of hemisphere) – hip.
  - Anterior paracentral gyrus – lower limb, On the medial surface + genitals.

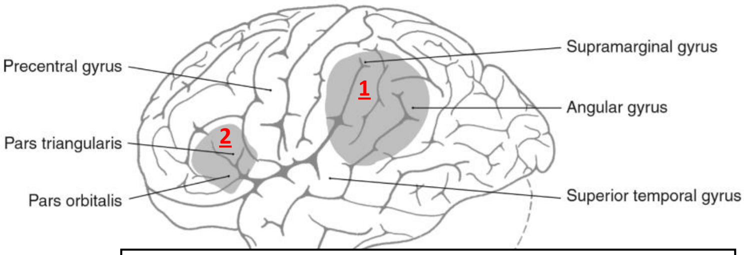

Motor map in precentral gyrus
Fingers
Hand
Wrist
Elbow
Shoulder
Trunk
Hip
An
Knee
Foot
Toes
Genit
Thumb
Neck
Brow
Eye
Face
Lips
Jaw
Tongue
Swallowing
Primary motor cortex (precentral gyrus)

*Supplied by anterior and middle cerebral arteries. damage to the arteries cause dysfunction of the corresponding organ.

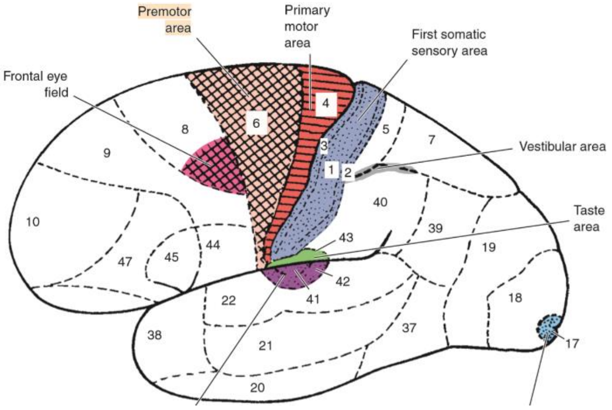
  - Lower limb – Supplied by branches of anterior cerebral artery – A4, A5, specifically Callosomarginal artery.
  - Head, Upper limb and Trunk – Supplied by branches of middle cerebral artery – M4, mainly rolandic and prerolandic branches.


Precentral gyrus
Hand
Wrist
Arm
Trunk
Hip
Leg
Foot
Anterior paracentral gyrus
Anterior cerebral artery (A_4/A_5)
Neck
Face
Lips
Jaw
Tongue
Throat
Lateral sulcus
M_2 branches of middle cerebral artery
B

- Premotor area – Brodmann area 6. Responsible for preparation of movement.
- Supplementary motor cortex – Brodmann area 6. responsible for planning sequence of movements.
- Frontal eye field – Brodmann area 6 and partly 8. in the Precentral sulcus and Middle Frontal gyrus. Project to C.N. 3,4,6 for conscious control of eye movement.
- Broca area – Brodmann area 44 + 45. On the inferior frontal gyrus, opercular and triangular parts. Responsible for verbal communication – movement of speech, sound and pronunciation.
- Prefrontal cortex – Brodmann areas 9,10,11,12. involved in control of behaviour, attention, thinking and motion. Communicates with the limbic system (amygdala) and other lobes of the hemisphere.


Precentral gyrus
Pars triangularis
Pars orbitalis
1
2
Supramarginal gyrus
Angular gyrus
Superior temporal gyrus

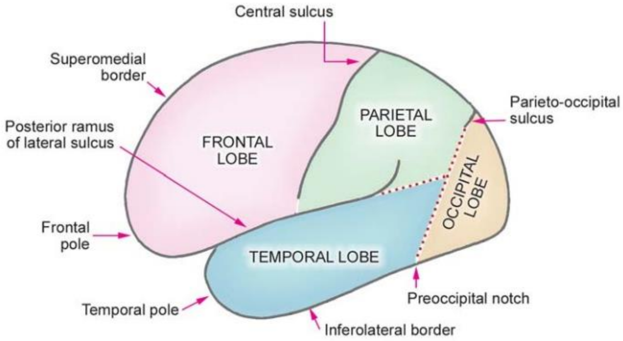
Gray: Wernicke area at the back (1), broca at the front (2)


Premotor area
Primary motor area
First somatic sensory area
Frontal eye field
Vestibular area
Taste area
4
6
8
9
10
3
1
2
5
7
40
39
43
44
45
47
42
41
22
38
21
20
37
19
18
17

Tracts:

- Corticospinal.
- Corticonuclear.

Topic 14 – Gyri (with their corresponding Brodmann area numbers) and sulci of the parietal lobe.


Central sulcus
Superomedial border
Posterior ramus of lateral sulcus
FRONTAL LOBE
PARIETAL LOBE
Parieto-occipital sulcus
OCCIPITAL LOBE
Frontal pole
TEMPORAL LOBE
Temporal pole
Preoccipital notch
Inferolateral border

Hain's 214, Barr’s 216

- Covered by the parietal bone.

Borders:

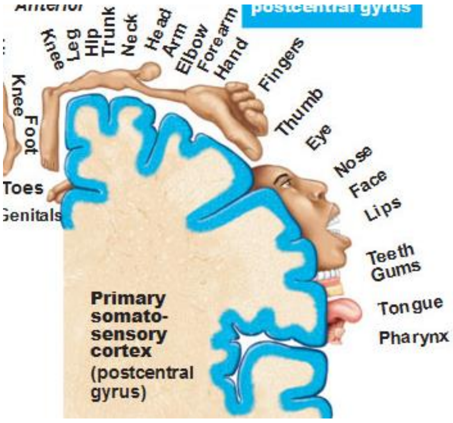
- Anterior: Central Sulcus.
- Posterior: imaginary line between Parieto-Occipital sulcus and Pre-Occipital notch.
- Inferior: Lateral Sulcus and its continuation to the Parieto-Occipital line.
- On the medial surface: frontal lobe anteriorly, and Parietooccipital sulcus posteriorly, Cingulate gyrus of limbic lobe inferiorly.

Gyri and sulci:

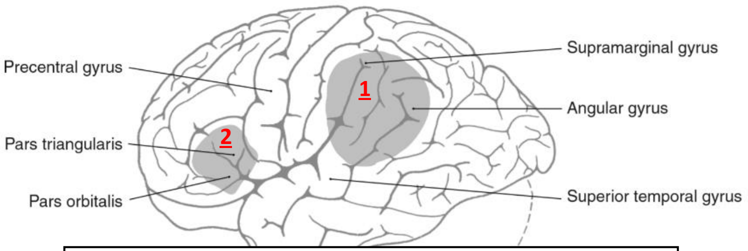
- Postcentral gyrus – posterior to the central sulcus, anterior to the postcentral sulcus. on the medial surface it Forms the posterior paracentral gyrus, bordered by central sulcus and marginal ramus of cingulate sulcus.
- Superior parietal lobule – composed of few gyri, that form the Precuneus on the medial side of hemispheres.
- Intraparietal sulcus – separates the Superior and Inferior Parietal lobules.
- Inferior Parietal lobule – made of the Angular and Supramarginal gyri.
- Supramarginal gyrus – around the extension of the lateral sulcus.
- Angular gyrus – around the extension of the Superior Temporal sulcus.
- Parieto-Occipital sulcus – marks the posterior border on the medial surface.

Brodmann areas:

- Primary Somatosensory cortex: Brodmann areas 3,1,2, Cover the postcentral and posterior paracentral gyri.
  Function: forms somatotopically pattern of sensation that comes from the whole body:
  - Throat and face are represented in the lower part,
  - Hand and arm at the middle,
  - Head, neck and trunk on the upper part,
  - Foot and genitals on the medial surface of hemisphere.
- Somatosensory association cortex – Brodmann area 5.


Anterior
postcentral gyrus
Knee
Leg
Hip
Trunk
Neck
Head
Arm
Elbow
Forearm
Hand
Fingers
Thumb
Eye
Nose
Face
Lips
Teeth
Gums
Tongue
Pharynx
Knee
Foot
Toes
Genitals
Primary somato-sensory cortex (postcentral gyrus)

- Wernicke area: Brodmann areas 40 – Supramarginal gyrus, and 39 – Angular gyrus (both belong to inferior parietal lobule).
  The Wernicke area also includes areas 22,21 on the temporal lobe.
  Function: auditory association cortex, part of the receptive language area (= sensory language area, posterior speech area). Important for reading and writing aspects of language. Responsible for language understanding and words interpretation.


Precentral gyrus
Pars triangularis
Pars orbitalis
1
2
Supramarginal gyrus
Angular gyrus
Superior temporal gyrus

Gray: Wernicke area at the back (1), broca at the front (2)

Tracts:

- All ascending sensory tract to cortex.
- From Intralaminar nuclei (of thalamus).

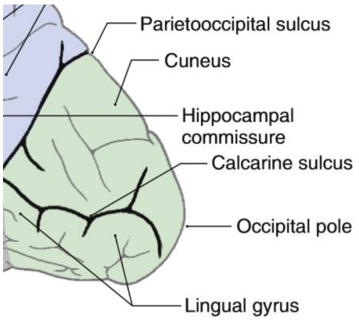
Topic 15 – Gyri (with their corresponding Brodmann area numbers) and sulci of the occipital lobe and the insular lobe.

Occipital lobe

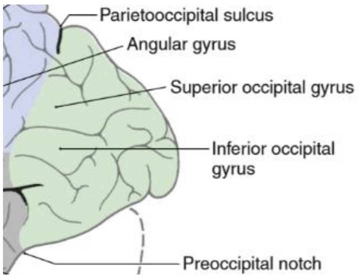
Hain's 217, Barr's

- Covered by the occipital bone.
- Forms the caudal portion of hemisphere; its caudal end is the Occipital pole of the brain.

Medial Surface


Parietooccipital sulcus
Cuneus
Hippocampal commissure
Calcarine sulcus
Occipital pole
Lingual gyrus

Lateral Surface


Parietooccipital sulcus
Angular gyrus
Superior occipital gyrus
Inferior occipital gyrus
Preoccipital notch

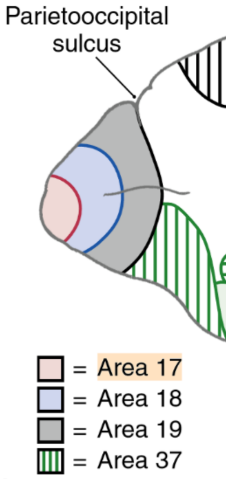
Borders:

- Anteriorly: line between the Parieto-occipital sulcus and the Preoccipital notch. On the medial surface it is the Parietooccipital sulcus and its continuation.
- Posteriorly: Occipital pole.
- Superior and Inferior: margin of the hemisphere.

Gyri and sulci:

- Superior and Inferior Occipital Gyri – on the lateral surface.
- Cuneus – on the medial surface. Above the Calcarine sulcus.
- Lingual gyrus – on the medial inferior surface. Below the Calcarine sulcus.
- Parieto-occipital sulcus – separates the cuneus and Precuneus. meets the Calcarine sulcus.
- Calcarine sulcus – on the medial surface, between the Cuneus and Lingual Gyrus.

Lateral Surface


Parietooccipital sulcus
= Area 17
= Area 18
= Area 19
= Area 37

Brodmann areas:

- Primary visual cortex: Brodmann area 17. Superior and inferior to the Calcarine sulcus.
- Secondary visual cortex: Brodmann area 18.
- Tertiary visual cortex: Brodmann area 19.

Insula – Insular lobe

Hain's 216

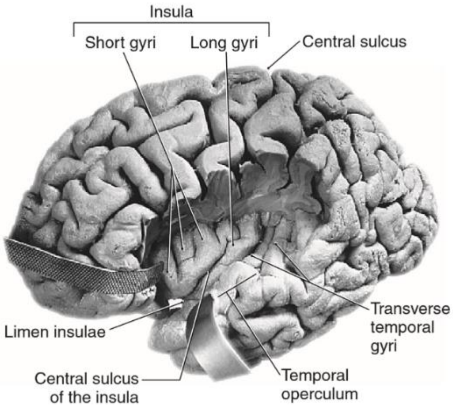
- Found internal to the lateral sulcus.
- Function: not completely clear. Receive nociceptive and viscerosensory input.
- Opercula – parts of the frontal, parietal and temporal lobes that cover the insula.

Borders:

- Circular sulcus of the insula – separates the insula from the Opercula of the frontal, parietal, and temporal lobes.
- Limen insula – area at which the inferior surface of hemisphere is continuous with the insular cortex – long gyrus of insula continues with piriform area of Parahippocampal gyrus.

Gyri and sulci:

- Long gyri – in the posterior part.
- Short gyri – in the anterior part.
- Central sulcus of the insula – separates the short and long gyri.


Insula
Short gyri
Long gyri
Central sulcus
Transverse temporal gyri
Limen insulae
Central sulcus of the insula
Temporal operculum

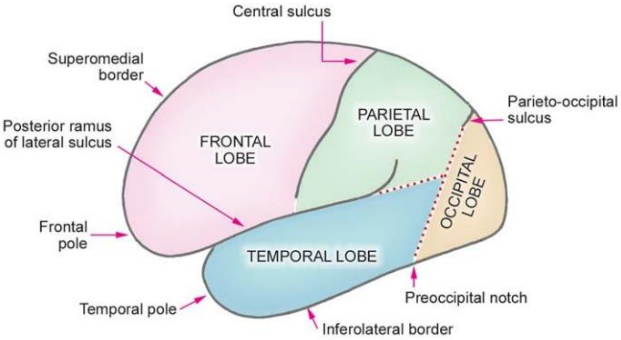
Topic 16 – Gyri (with their corresponding Brodmann area numbers) and sulci of the temporal lobe.

Hain's 215, 297, Barr's 217.

- Covered by the temporal bone.

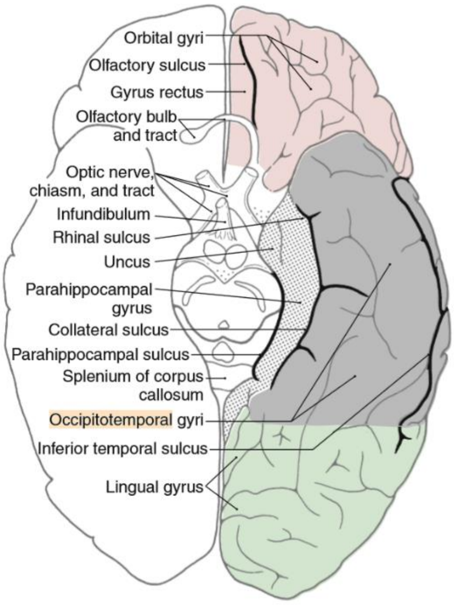
Borders:

- Superior: Lateral fissure, and its continuation posteriorly.
- Inferior: Inferior margin of hemisphere.
- Anterior: Temporal pole.
- Posterior: Parieto-Occipital line – between the Parieto-Occipital sulcus and the Preoccipital notch.
- Medial: Collateral sulcus. Separate it from the limbic lobe.

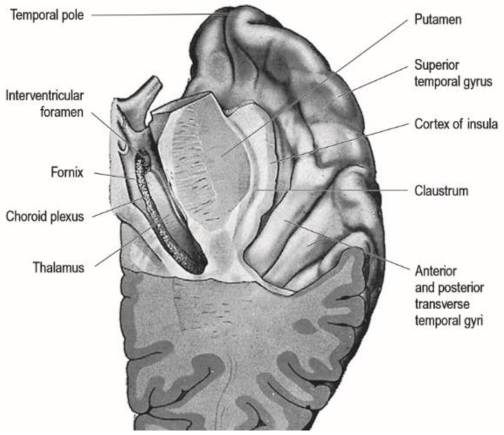

Central sulcus
Superomedial border
Parieto-occipital sulcus
Posterior ramus of lateral sulcus
FRONTAL LOBE
PARIETAL LOBE
OCCIPITAL LOBE
Frontal pole
TEMPORAL LOBE
Preoccipital notch
Temporal pole
Inferolateral border

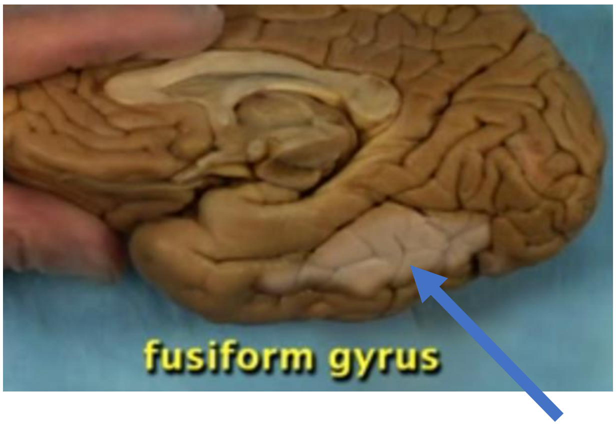
Gyri and sulci:

- Superior, middle and inferior temporal gyri.
- Superior temporal sulcus – separate the superior and middle temporal gyri. It extends posteriorly and ends in the Angular gyrus of the Inferior Parietal lobule.
- Middle Temporal sulcus – between the middle and inferior gyri.
- Inferior Temporal sulcus – separates the inferior temporal gyrus from the Occipitotemporal gyri.
- Occipitotemporal gyri – medial and lateral. extends from temporal to occipital lobe, on the inferior surface.
    - Lateral – continues with the inferior temporal gyrus.
    - Medial – also called Fusiform gyrus.
- Transverse temporal gyri of Heschl – Anterior and Posterior. On the superior surface of the lobe. Enter the depth of lateral fissure.
- Collateral sulcus – the medial border of the temporal lobe. Separates it from the limbic lobe.


Orbital gyri
Olfactory sulcus
Gyrus rectus
Olfactory bulb and tract
Optic nerve, chiasm, and tract
Infundibulum
Rhinal sulcus
Uncus
Parahippocampal gyrus
Collateral sulcus
Parahippocampal sulcus
Splenium of corpus callosum
Occipitotemporal gyri
Inferior temporal sulcus
Lingual gyrus

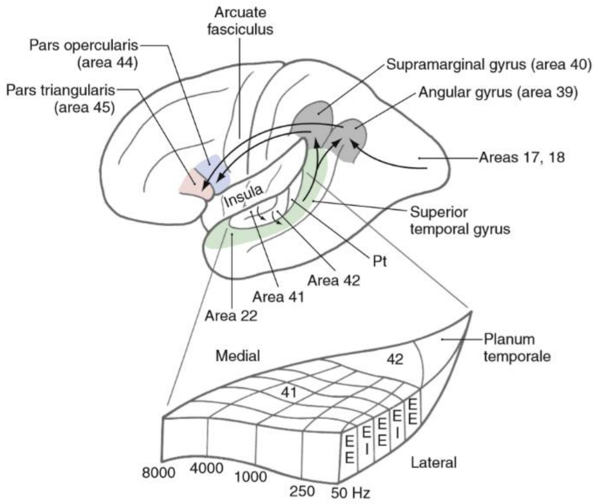
Anterior and Posterior transverse temporal gyri of Heschl.
Horizontal section showing the left temporal lobe, viewed from above.

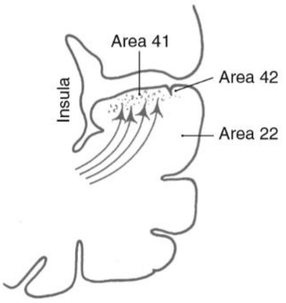

Temporal pole
Interventricular foramen
Fornix
Choroid plexus
Thalamus
Putamen
Superior temporal gyrus
Cortex of insula
Claustrum
Anterior and posterior transverse temporal gyri


fusiform gyrus

Brodmann areas:

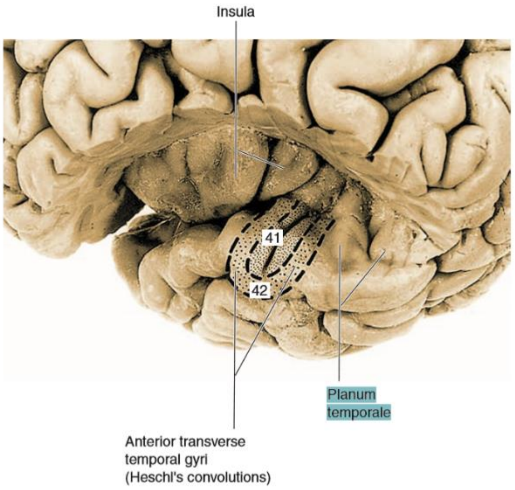
- Primary auditory cortex – Brodmann area 41.
  On the Anterior Transverse temporal gyrus of Heschl.
  Responsible for perception of hearing.
- Secondary auditory cortex – Brodmann area 42. On the Posterior Transverse gyrus, and the posterior part of the Superior temporal gyrus.
- Auditory association cortex – Brodmann area 22. On the Superior Temporal gyrus. It is part of Wernicke area – speech receptive area. Receives auditory and visual information. The other parts are on the parietal lobe – areas 39 and 40.
- Planum Temporale – smooth part on the superior temporal gyrus which is also part of the Wernicke's area and include parts of areas 22 and 42. It is Usually bigger on the left hemisphere.
- Area 21 – Middle Temporal gyrus. Also part of Wernicke's area.
- Area 20 – Inferior Temporal gyrus. It is visual association area.


Arcuate fasciculus
Pars opercularis (area 44)
Pars triangularis (area 45)
Supramarginal gyrus (area 40)
Angular gyrus (area 39)
Areas 17, 18
Insula
Superior temporal gyrus
Pt
Area 42
Area 41
Area 22
Planum temporale
Medial
42
41
E
I
E
Lateral
8000
4000
1000
250
50 Hz


Area 41
Area 42
Area 22
Insula

Tracts:

- Auditory pathway.


Insula
41
42
Planum temporale
Anterior transverse temporal gyri (Heschl's convolutions)

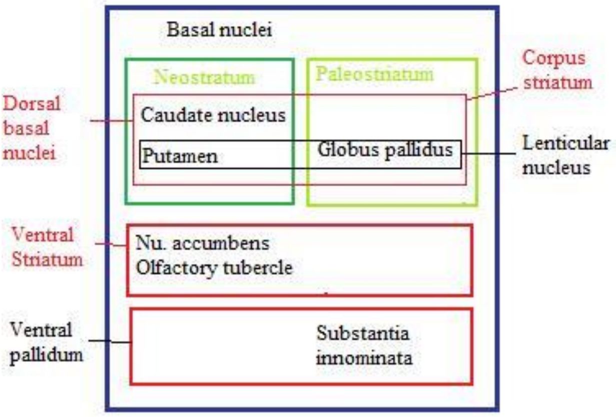
Topic 17 – Demonstration of basal ganglia and internal capsule (correct order of the tracts) on a Flechsig's cut and coronal sections.

Hain's 354, 221, Barr's 201

Basal ganglia

- The Basal Ganglia are collection of grey matter nuclei found in the telencephalon, diencephalon and midbrain.
- Function: involved in modulation of motor and behaviour functions, in sensorimotor integration, and in cognitive functions. Primarily effect through inhibition.
- They Interconnect with the:
  - Cortex
  - Thalamus
  - Brain stem
- Some associated structures around it are involved in their pathways – Subthalamic nucleus, Substantia nigra, Amygdala and Pedunculopontine Tegmental nucleus.

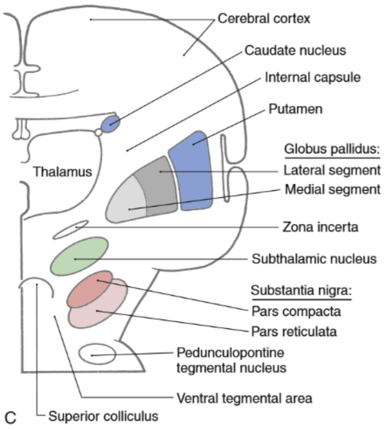
Paler : internal
darker : external


Basal nuclei
Neostratum
Paleostriatum
Corpus striatum
Dorsal basal nuclei
Caudate nucleus
Putamen
Globus pallidus
Lenticular nucleus
Ventral Striatum
Nu. accumbens
Olfactory tubercle
Ventral pallidum
Substantia innominata

Basal Ganglia division – dorsal and ventral striatum. Each is associated with additional structures.

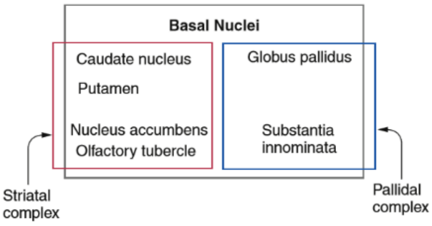
- Dorsal nuclei –
  (1) caudate,
  (2) putamen,
  (3) Globus Pallidus (Paleostriatum).
  divisions:
  - Lenticular nucleus – Globus Pallidus + Putamen.
  - Corpus striatum – Caudate + Lenticular nucleus.
  - Neostriatum – Caudate + Putamen.

  - associated with the dorsal basal nuclei are the: Substantia nigra, Subthalamic nucleus, parabrachial pontine reticular formation.


Cerebral cortex
Caudate nucleus
Internal capsule
Putamen
Globus pallidus:
Lateral segment
Medial segment
Thalamus
Zona incerta
Subthalamic nucleus
Substantia nigra:
Pars compacta
Pars reticulata
Pedunculopontine tegmental nucleus
Ventral tegmental area
Superior colliculus
C

The dorsal basal nuclei + their associated structures

- Ventral nuclei – located inferior to the Anterior commissure.
  separated into 2 groups:
  1. Ventral striatum – Nucleus Accumbens + Olfactory Tubercle.
  2. Ventral pallidum – Substantia Innominate and inside it the Basal nucleus of Meynert.
  -associated with the Amygdala and Ventral Tegmental area.
- Functional division – 2 complexes: striatal complex and Pallidal complex.

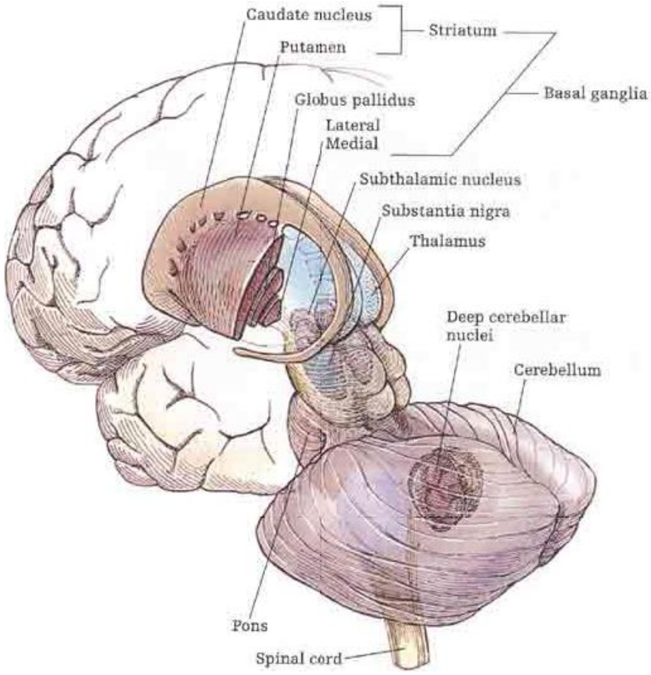

Basal Nuclei
Caudate nucleus
Putamen
Nucleus accumbens
Olfactory tubercle
Globus pallidus
Substantia innominata
Striatal complex
Pallidal complex

The nuclei:

1. Caudate:
   Located in the lateral wall of the lateral ventricle and the C shape of the caudate nucleus follows the C shape of the lateral ventricle (without the posterior horn). It has 3 parts:

   - Head – forms bulge in the anterior horn of the lateral ventricle.
   - Body – from the IV foramen and posteriorly, there it becomes smaller.
   - Tail – in the lateral wall of the atrium of the lateral ventricle, continues inferiorly in the wall of the inferior horn of the lateral ventricle.)

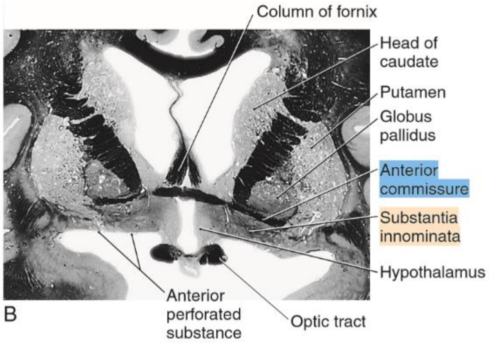
2. The lenticular (lentiform) nucleus:
   - Located in the base of the hemisphere and is surrounded by white matter.
     Borders:
     Medially: Internal Capsule.
     Laterally: separated from the Claustrum by the external capsule.
   - Has 2 parts:
     (1) Putamen: extends more lateral.
     (2) Globus Pallidus: smaller, more medial.
     divided by medullary lamina, a thin sheet white matter, into:
     - medial (internal) part.
     - lateral (external) part.
   - Putamen and Globus Pallidus are separated by a thin lamina of white matter.


Caudate nucleus
Putamen
Striatum
Basal ganglia
Globus pallidus
Lateral
Medial
Subthalamic nucleus
Substantia nigra
Thalamus
Deep cerebellar nuclei
Cerebellum
Pons
Spinal cord

3. The Claustrum:
   - Between the Putamen and Insular cortex.
   - Considered by some sources as part of basal ganglia. Connects to many areas in cortex, as well as the hippocampus, the amygdala, and the caudate nucleus.
   - Surrounded by external and extreme capsule.

4. Nucleus accumbens:
   - Located anteriorly in the hemisphere where the Putamen is continuous with the head of the Caudate nucleus, and the Internal Capsule above it (On coronal section).
   - Releases GABA.
   - This cell group is closely opposed to the Septal Nuclei and the nucleus of the diagonal band. both extend into the base of the Septum Pellucidum.

5. Substantia innominata:
    - located internal to the anterior perforated substance , it is hard to find it. Surrounding structures:
        - Superiorly – Anterior Commissure.
        - Laterally – Amygdala.
        - Medially – Hypothalamus.
        - Anteriorly – Nucleus Accumbens.
    - Basal nucleus of Meynert – important group of cells in the Substantia Innominata. Has many neurons that release Ach, that are lost in Alzheimer disease.


Column of fornix
Head of caudate
Putamen
Globus pallidus
Anterior commissure
Substantia innominata
Hypothalamus
B
Anterior perforated substance
Optic tract

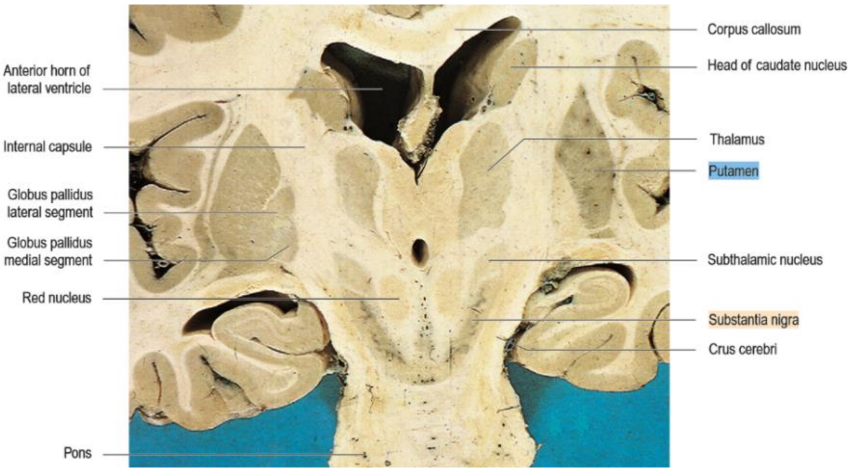
**according to the lecture of the department, the Amygdala, Subthalamic nucleus and Substantia Nigra are also part of the basal ganglia.

- Blood supply:
    - The telencephalon area:
      (1) Medial striate artery, branch of A2.
      (2) Lenticulostriate branches of M1 (Part of middle cerebral artery).
      (3) Anterior choroidal artery, branch of ICA.
    - Diencephalic and mesencephalic regions:
      (1) Posteromedial branches of P1 segment (posterior cerebral artery branch).
      (2) Posterior communicating artery.

Associated nuclei – not the basal nuclei but are important for their functions:

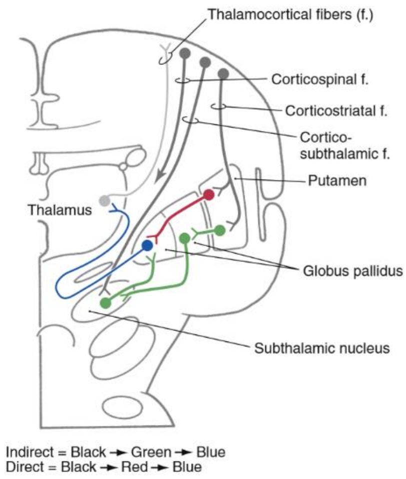
1. Subthalamic nucleus:
    - In the diencephalon.
    - Flattened, lens shaped cell group anterior to the Substantia Nigra.
    - Medial to the Internal Capsule and capped by thin sheet of fibers called the Lenticular Fasciculus. It is lateral to Hypothalamus and Red nucleus, and Inferior to Thalamus.
    - Excitatory glutamate NT. Inhibited by external pallidus.

2. Substantia Nigra:
    - In the crus cerebri of midbrain, caudal to the Subthalamic nucleus.
    - Part of Nigral complex, that include also the ventral tegmental area.
    - Has 2 parts – reticular part (GABA), and compact part (Dopamin).
      Melanin is the precursor of Dopamin, and it makes the black color of the nucleus.


Anterior horn of lateral ventricle
Internal capsule
Globus pallidus lateral segment
Globus pallidus medial segment
Red nucleus
Pons
Corpus callosum
Head of caudate nucleus
Thalamus
Putamen
Subthalamic nucleus
Substantia nigra
Crus cerebri

Internal capsule

Hain's 206, 219.

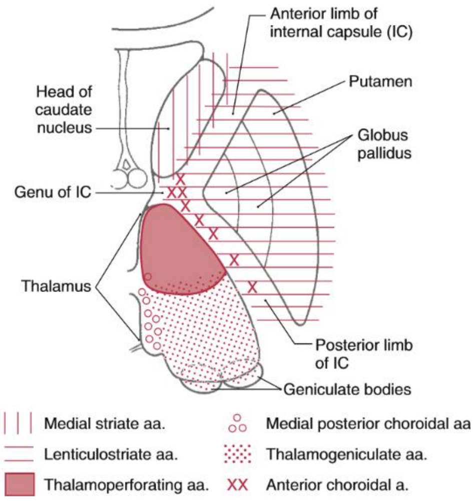

Thalamocortical fibers (f.)
Corticospinal f.
Corticostriatal f.
Cortico-subthalamic f.
Putamen
Thalamus
Globus pallidus
Subthalamic nucleus
Indirect = Black → Green → Blue
Direct = Black → Red → Blue

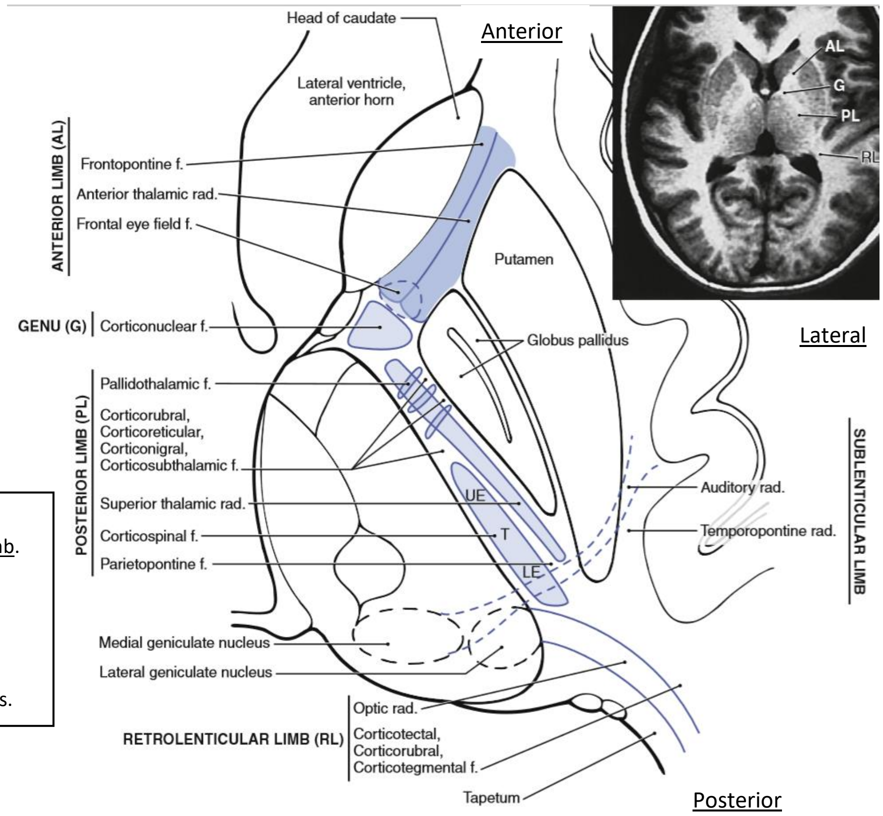
- It is the structure through which pass the Projection fibers of the hemispheres – White matter that comes from the cortex down-ward (Corticofugal) and from other structures upward to the cortex (Corticopetal).
- Allows communication of cortex with other brain parts (Diencephalon, Cerebellum, Brain stem) and Spinal Cord.
- Corona Radiata – Fibers between the internal capsule and the cortex.
- It has a V shape, that include 4 parts:

  1. Anterior limb – between the Caudate and Lenticular nuclus. Contains the following pathways:
     - a) Anterior Thalamic radiation – fibers between cortex (frontal lobe and cingulate gyrus) to thalamic nuclei – dorsomedial and anterior.
     - b) Frontopontine fibers.
  2. Posterior limb – between the Thalamus and Lenticular nucleus. Larger and more complex. Contains the following pathways:
     - a) Corticospinal tract (somatomotor).
     - b) Central Thalamic radiation (connect cortex with dorsal thalamic nuclei).
     - c) Ascenting tracts from spinal cord: dorsal column-medial lemniscus system + anterolateral system.
     - c) Auditory radiation – from Medial Geniculate body to auditory cortex.
     - d) Optic radiation – from Lateral Geniculate body to visual cortex. broadmann 17 →
  3. Genu – between the anterior and posterior limbs. lateral to Anterior Thalamic nucleus, at the level of the interventricular foramen. Contain: Corticonuclear fibers – from motor cortex to motor nuclei of cranial nerves.
  4. Retrolenticular limb – caudal (retro) to lenticula nucleus. Through it the optic radiation passes.
  5. Sublenticular limb – inferior (sub) to lenticular nucleus. Through it the auditory radiation passes.

  Both the retor and sub lenticular limbs Used to be considered as part of the posterior limb (you can mentione the optic and auditory radiations as part of the posterior limb).

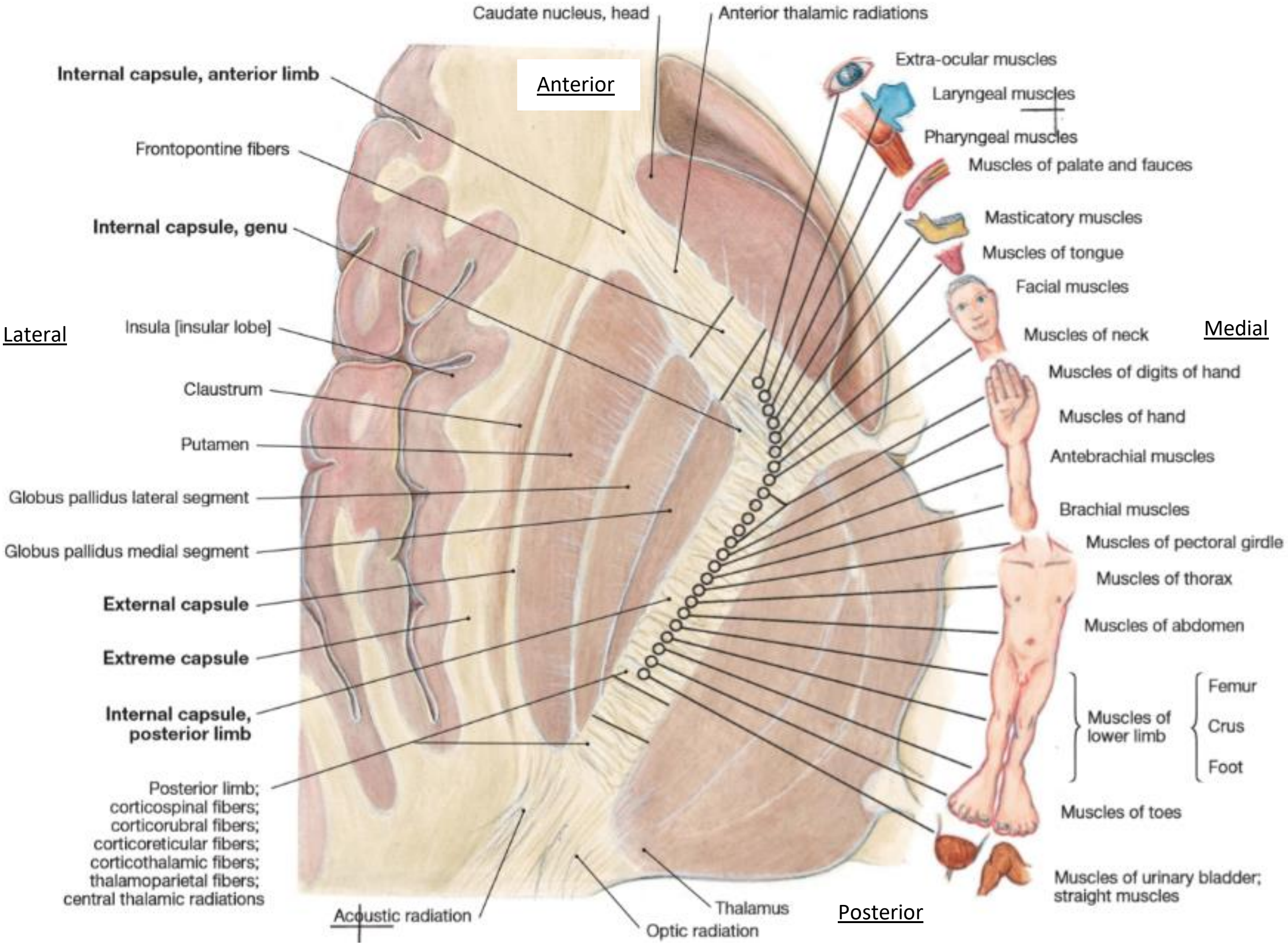
- Blood supply:
  - **Genu and posterior limb:** Lenticulostriate arteries (M1).
  - Anterior region of the posterior limb and the retrolenticular limb which is supplied by the anterior choroidal artery (branch of ICA).
  - **Anterior limb:** Lenticulostriate arteries, Medial Striate artery (usually a branch of A2).

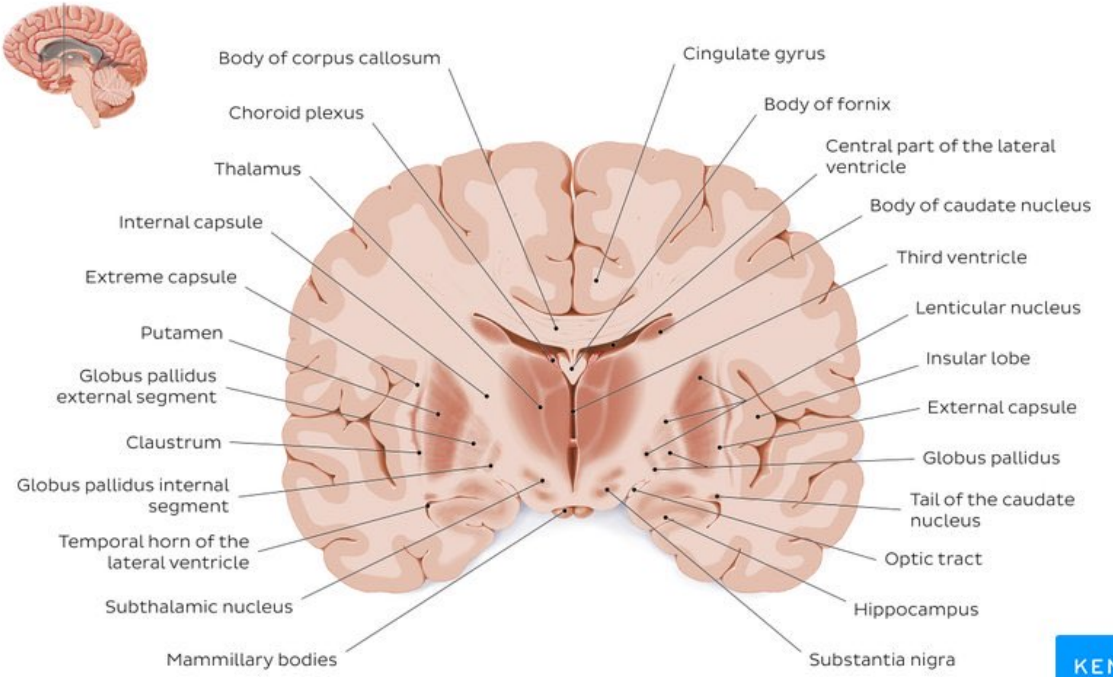

Anterior limb of internal capsule (IC)
Putamen
Head of caudate nucleus
Globus pallidus
Genu of IC
Thalamus
Posterior limb of IC
Geniculate bodies
||| Medial striate aa.
— Lenticulostriate aa.
🟥 Thalamoperforating aa.
∘∘ Medial posterior choroidal aa
⁘ Thalamogeniculate aa.
XX Anterior choroidal a.


Medial
Lateral
Anterior
Posterior
Head of caudate
Lateral ventricle, anterior horn
ANTERIOR LIMB (AL)
Frontopontine f.
Anterior thalamic rad.
Frontal eye field f.
Putamen
GENU (G)
Corticonuclear f.
Globus pallidus
POSTERIOR LIMB (PL)
Pallidothalamic f.
Corticorubral,
Corticoreticular,
Corticonigral,
Corticosubthalamic f.
Superior thalamic rad.
Corticospinal f.
Parietopontine f.
UE
T
LE
SUBLENTICULAR LIMB
Auditory rad.
Temporopontine rad.
Medial geniculate nucleus
Lateral geniculate nucleus
RETROLENTICULAR LIMB (RL)
Optic rad.
Corticotectal,
Corticorubral,
Corticotegmental f.
Tapetum
AL
G
PL
RL

Tracts mentioned in the department list –

- Corticospinal tract – cortex to spinal cord. Posterior limb.
- Corticonuclear (=corticobulbar) tract – cortex to motor nuclei of cranial nerves. Genu.
- Frontopontine tract – frontal cortex to pons, then cerebellum. Anterior limb.
- Temporo-parieto-occipitopontine tract = cortex to pons.


Caudate nucleus, head
Anterior thalamic radiations
Anterior
Lateral
Medial
Posterior
Internal capsule, anterior limb
Frontopontine fibers
Internal capsule, genu
Insula [insular lobe]
Claustrum
Putamen
Globus pallidus lateral segment
Globus pallidus medial segment
External capsule
Extreme capsule
Internal capsule, posterior limb
Posterior limb; corticospinal fibers; corticorubral fibers; corticoreticular fibers; corticothalamic fibers; thalamoparietal fibers; central thalamic radiations
Acoustic radiation
Optic radiation
Thalamus
Extra-ocular muscles
Laryngeal muscles
Pharyngeal muscles
Muscles of palate and fauces
Masticatory muscles
Muscles of tongue
Facial muscles
Muscles of neck
Muscles of digits of hand
Muscles of hand
Antebrachial muscles
Brachial muscles
Muscles of pectoral girdle
Muscles of thorax
Muscles of abdomen
Muscles of lower limb
Femur
Crus
Foot
Muscles of toes
Muscles of urinary bladder; straight muscles


Body of corpus callosum
Choroid plexus
Thalamus
Internal capsule
Extreme capsule
Putamen
Globus pallidus external segment
Claustrum
Globus pallidus internal segment
Temporal horn of the lateral ventricle
Subthalamic nucleus
Mammillary bodies
Cingulate gyrus
Body of fornix
Central part of the lateral ventricle
Body of caudate nucleus
Third ventricle
Lenticular nucleus
Insular lobe
External capsule
Globus pallidus
Tail of the caudate nucleus
Optic tract
Hippocampus
Substantia nigra

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Coronal sections, from things we saw in the class. This is not an exact description but can help to aquire general perspective of the relations of different structures.

(1) round superior surfase, flat inferior surface.

- longitudinal cerebral fissure – seperates the 2 hemisphers.
    - In it – branches of anterior cerebral artery.
- Superiorly – superior, middle and inferior frontal gyri are seen, separated by superior and inferior frontal sulci.
- Inferiorly – straight gyrus, olfactory sulcus, orbital gyrus.

(2) cavities of lateral ventricle appear.

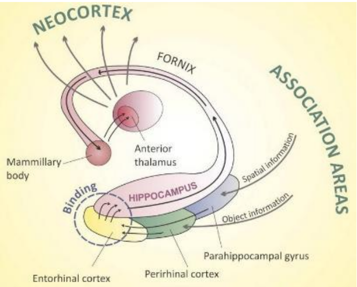
- In the middle – Genu and rostrum of corpus callosum. Above it – Pericallosal artery.
- Sulcus of Corpus Callosum above the corpus callosum. Above it – cingulate gyrus and cingulate sulcus.
- Anterior horn of lateral ventricle.
- Inferiorly – olfactory tract in the olfactory sulcus.

(3) Septum Pellucidum appears

- Anterior horn of lateral ventricle is horizontal in this section. The anterior horn has a little more angular orientation.
- Septum Pellucidum separates the left and right horns.
- Corpus striatum is seen – Caudate head (appear first, it is more anterior) the and putamen. The 2 are connected by Stria.
- Nucleus Accumbens – little more posterior. It is inferior, looks like fusion of caudate and putamen.
- Internal capsule is seen.
- Corpus callosum split into 2 – anterior forceps.
- Lateral sulcus begin to appear.

(4) Anterior commissure appears

- Anterior horns are separated by septum Pellucidum.
- Globus pallidus appear. In the Lentiform nucleus it is more medial and inferior, the putamen is lateral and superior.
- Anterior commissure is found bellow the Globus.
- Substantia innominata (ventral pallidum) is found inferior to the anterior commissure.
- Claustrum is found between the Lentiform nucleus and insular cortex, surrounded by the external and extreme capsules.
- Caudate head becomes the body when anterior horn ends.
- Lateral sulcus lead to the insular cortex.
- Optic chiasm is seen at the base. Next to it – internal carotid artery.
- Olfactory tract ends. It splits into medial and lateral Stria.
- Posterior to the bifurcation of the olfactory tract – anterior perforated substance.



- The Uncus of parahippocampal gyrus is found, together with it is the Entorhinal cortex.
- Anterior to the hypothalamus – Bed nucleus of Stria Terminalis (tracts of hypothalamus nuclei to nucleus Accumbens and the septal nuclei, not important).

(5) 3^{rd} ventricle appear at the level of the interventricular foramen

- Interventricular foramen.
- Choroidal plexus appears and enter the foramen.
- Cavity of septum Pellucidum might appear.
- Inferiorly – the optic chiasm. Posterior to it – infundibulum of pituitary gland.
- Supraoptic chiasm.
- Lateral to the chiasm – anterior perforated substance.
- The floor of 3^{rd} ventricle (anterior to posterior) – optic chiasm, infundibulum, mammillary bodies. Below it – the anterior commissure.

On the other side: thalamus appear.

- Central part of lateral ventricle. More horizontal orientation. Its floor (lateral to medial) – (1) body of caudate, (2) Stria Terminalis, (3) Thalamostriate vein, (4) Lamina Affixa Thalami (covers the thalamus), (5) Stria Medullaris thalami (between the superior and medial parts of thalamus).
- Inferior horn of lateral ventricle. Its floor – pes of hippocampus. Its roof – the tail of Caudate. Amygdala – anterior to inferior horn.
- Fornix – inferior to corpus callosum. Has 2 columns, between them and little more anterior is the anterior commissure.
- In the ventricle – 2 Tenia – a. Tenia Fornicis inferior and media, b. Tenia Choroidea superior and lateral.
- Anterior thalamic nuclei. More posterior – lateral and medial groups of nuclei appear.
- Interthalamic adhesion – at the level of mammillary body.
- Mammilothalamic tract – to anterior nucleus of thalamus.
- Lentiform nucleus – Globus Pallidus has internal and external parts.
- Posterior perforated substance – above Substantia Nigra, between the Interpeduncular Fossa.

(6) Center of thalamus

- Hypothalamus – below the thalamus.
- Subthalamus – below the thalamus, lateral to hypothalamus.
- Zona Incerta – above the subthalamus.
- Ansa Reticularis – between Globus Pallidus and thalamus. Bellow the substantia nigra.
- Forel H2 – between Globus pallidus and thalamus. Between zona Incerta and subthalamus.
- Basilar artery in the brain stem.
- Cerebral peduncles. (might be more posterior) Between them the interpeduncular fossa with the posterior perforated substance. It is above the substantia nigra.
- The red nucleus is above the substantia nigra, and medial to subthalamus.

- Thalamus nuclei – VPM, VPL, LP.

(7) Pineal gland, colliculi and Habenulla.

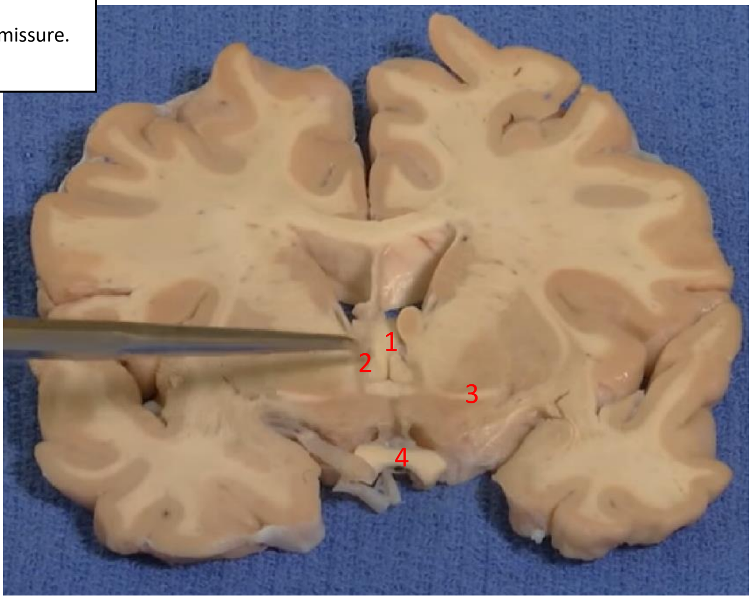
- Splenium of corpus callosum.
- Atrium of lateral ventricle – connection of inferior, posterior and lateral horn.
- Pineal gland. On the surface of Superior Colliculi.
- Cerebral Aqueduct – bellow the posterior commissure.
- Habenular commissure is above the posterior commissure. Between them – pineal and supra pineal gland.
- At the posterior thalamus – Pulvinar, and below it the lateral and medial geniculate bodies. the lateral is triangular shape and striated. The medial is usually not seen.
- According to Clara, the Pulvinar (at the caudal end of the thalamus) is seen at the same level as the of the red nucleus and the substantia nigra. At the substantia nigra you might see a little hole. It is not the Cerebral Aqueduct, but the interpeduncular fossa! That looks like a little hole because of the section.

(8) Posterior horn

(9) Cerebellum

- Cerebellum is seen. Also the middle cerebellar peduncle.
- Splenium of corpus callosum.
- Rhomboid fossa and Superior Medullary velum – include the median eminence, Locus Ceruleus.
- On its surface – lingula of cerebellum.

1. fornix.
2. septal nuclei.
3. anterior commissure.
4. optic chiasm.



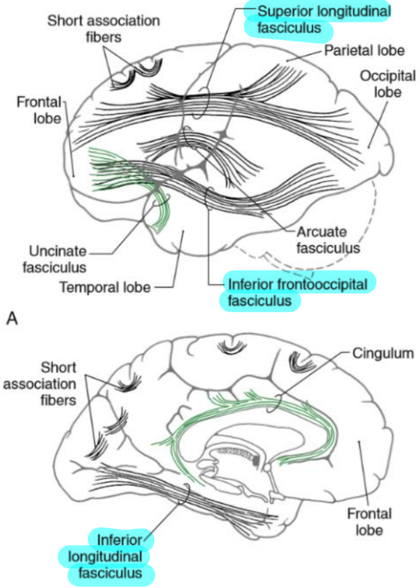
Topic 18 – Demonstration of the cerebral white matter connections (association, projection and commissural fibers).

Hain's 218. Barr's 247.

- The white matter is made by axons that travel in the CNS and convey information between different nuclei.
- In the telencephalon, there are 3 types of axons pathways:
  1. Association fibers: communicate between gray matter areas in the same hemisphere.
  2. Commissural fibers: communicate between gray matter areas in the other hemisphere.
  3. Projection fibers: communicate between gray matter of hemispheres and other structures. These are the fibers of descending (Corticofugal, from the hemispheres) and ascending (Corticopetal, to the hemispheres) pathways.

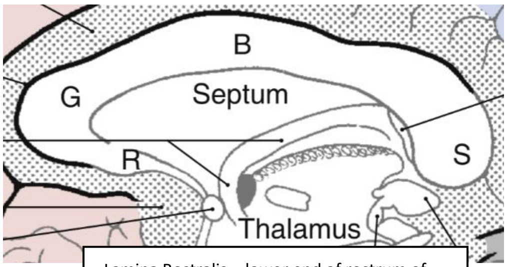
Association fibers:

- Connect areas on the same hemisphere. They are deep in the white mater, so they are not seen on our specimens.
- Types:
  - Short association fibers – connect adjacent gyri. Their general name is arcuate fibers. there are many.
  - Long association fibers – connect more distant areas.
    1. Cingulum – internal to the Cingulate gyrus. Continuing into the Parahippocampal gyrus and Hippocampus, Part of limbic system.
    2. Superior longitudinal fasciculus – connections of frontal, parietal, and occipital lobes.
    3. Inferior longitudinal fasciculus – connections of temporal and occipital lobes.
    4. inferior fronto-occipital fasciculus – connections of frontal and occipital lobes. Pass through the temporal lobe.
    5. Uncinate fasciculus – connections of frontal and temporal lobes.
    6. Arcuate fasciculus (thicker & longer) – connections of frontal and temporal lobes. connects Broca's and Wernicke's Areas.
    7. External capsule – separate the claustrum from the putamen.
    8. Extreme capsule – separate the claustrum from the insular cortex.


Short association fibers
Superior longitudinal fasciculus
Parietal lobe
Occipital lobe
Frontal lobe
Uncinate fasciculus
Temporal lobe
Arcuate fasciculus
Inferior frontooccipital fasciculus
A
Short association fibers
Cingulum
Inferior longitudinal fasciculus
Frontal lobe

Commissural fibers:

- Connect corresponding structure on the other hemisphere.
  1. corpus callosum – the largest commissural bundle.
     Location: superior to diencephalon. Part of the roof of lateral ventricle.
     Structure: rostrum, genu, body and splenium.
     Septum Pellucidum – continues beneath the body and separates the lateral ventricle of the two sides. In it is the cavity of Septum Pellucidum and the Septal nuclei (limbic system).
     Indusium Griseum – thin layer of gray matter. covers corpus callosum, extends from hippocampus. Has lateral and medial lamina. Not seen on specimen.


B
G
Septum
R
S
Thalamus

Lamina Rostralis – lower end of rostrum of corpus callosum, continue to lamina terminalis. Has no commissural fibers.

Fibers passing through the corpus callosum:

a. Minor (Frontal) forceps – fibers passing between the frontal lobes through the genu.

b. Major (Occipital) forceps – fibers passing between the occipital lobes through the splenium.

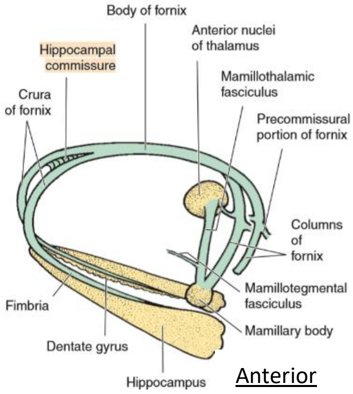
c. Tapetum – fibers in the lateral wall of atrium and posterior horn of the lateral ventricle, composed of fibers that cross in the splenium, and communicate between temporal lobes.

**the corpus callosum in females has more fibers than in males.

2. Anterior commissure –
   Location: inferior to rostrum of corpus callosum, at the anterior wall of 3rd ventricle.
   Function: Connects the frontal and temporal lobes of the 2 sides. Part of the olfactory pathway: Connects the olfactory cortex and olfactory bulbs of the hemispheres.

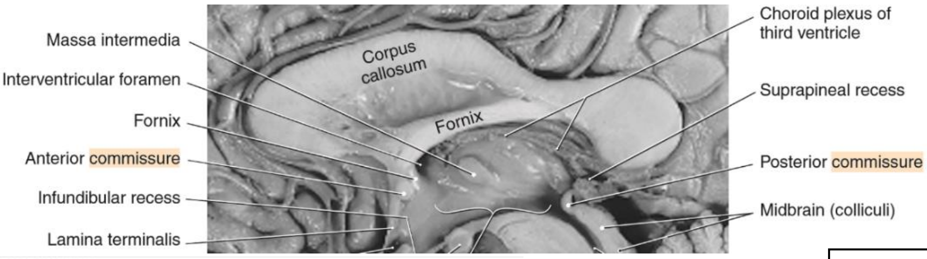
3. Hippocampal commissure – also called fornix commissure.
   Location: Pass inferior to splenium of corpus callosum. Pass between the crus of fornix. **notice – the fornix itself is **not** commissural fibers.
   Function: Connects the hippocampal formations to other structures.

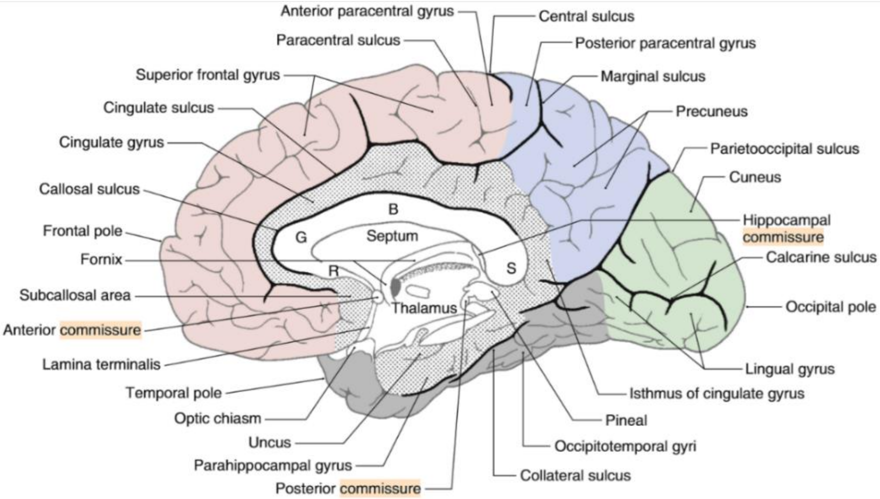
4. Posterior commissure –
   Location: inferior to the base of pineal gland and posterior to cerebral aqueduct.
   Function: participates in pupillary reflex – allows passage of information from oculomotor nucleus and Interstitial Nucleus of Cajal.


Body of fornix
Anterior nuclei of thalamus
Hippocampal commissure
Mamillothalamic fasciculus
Crura of fornix
Precommissural portion of fornix
Columns of fornix
Mamillotegmental fasciculus
Fimbria
Mamillary body
Dentate gyrus
Hippocampus
Anterior

Posterior commissure connects midbrain sides.
Habenular commissure connects diencephalon sides.

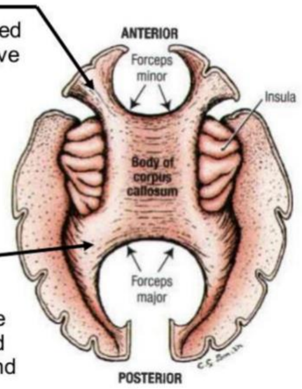
5. Habenular commissure –
   Location: superior to the Pineal gland and the Posterior Commissure.
   Function: interconnect the habenular nuclei.


Massa intermedia
Interventricular foramen
Fornix
Anterior commissure
Infundibular recess
Lamina terminalis
Corpus callosum
Fornix
Choroid plexus of third ventricle
Suprapineal recess
Posterior commissure
Midbrain (colliculi)


Anterior paracentral gyrus
Paracentral sulcus
Superior frontal gyrus
Cingulate sulcus
Cingulate gyrus
Callosal sulcus
Frontal pole
Fornix
Subcallosal area
Anterior commissure
Lamina terminalis
Temporal pole
Optic chiasm
Uncus
Parahippocampal gyrus
Posterior commissure
Central sulcus
Posterior paracentral gyrus
Marginal sulcus
Precuneus
Parietooccipital sulcus
Cuneus
Hippocampal commissure
Calcarine sulcus
Occipital pole
Lingual gyrus
Isthmus of cingulate gyrus
Pineal
Occipitotemporal gyri
Collateral sulcus
B
G
Septum
R
S
Thalamus

The shape of fibers passing through the corpus callosum. It is not dissected on our specimens so you don't really see it

- **Forceps minor** : the fibers directed laterally of the genu curve forward into the frontal lobes
- **Radiation of Corpus Callosum** The fibers of the body extend laterally.
- **Forceps major** : Traced laterally, the fibers in the splenium arch backward into the occipital lobe and form the.


ANTERIOR
Forceps minor
Insula
Body of corpus callosum
Forceps major
POSTERIOR

Topic 19 – Borders and structures of the lateral ventricle.

- The Lateral Ventricle is the cavity of the telencephalon. It is filled with CSF.
- It communicates with the third ventricle through the interventricular foramen.
- It has 5 parts –
  A. Anterior horn – extend into the frontal lobe.
  B. Central part. Also called Body.
  C. Posterior horn – extends into occipital lobe.
  D. Inferior horn – extends into the temporal lobe.
  E. Atrium – junction of the body and the posterior horn.
- Choroid plexus: produces the CSF that fills the ventricles.

  Tenia – the point of attachment of choroid plexus to the walls of the ventricle. It is named by the structure it is attached to:

  1. Tenia Choroidea – covers the floor of the central part of the ventricle. It is medial to Lamina Affixa Thalami (epithelium that covers the superior part of Thalamus).

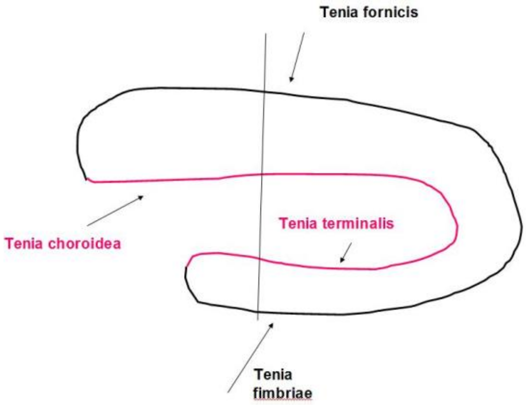
  The Tenia Choroidea continues to the inferior horn as the Tenia Terminalis, that attaches Stria Terminalis (fibers that connect amygdala and hypothalamus).

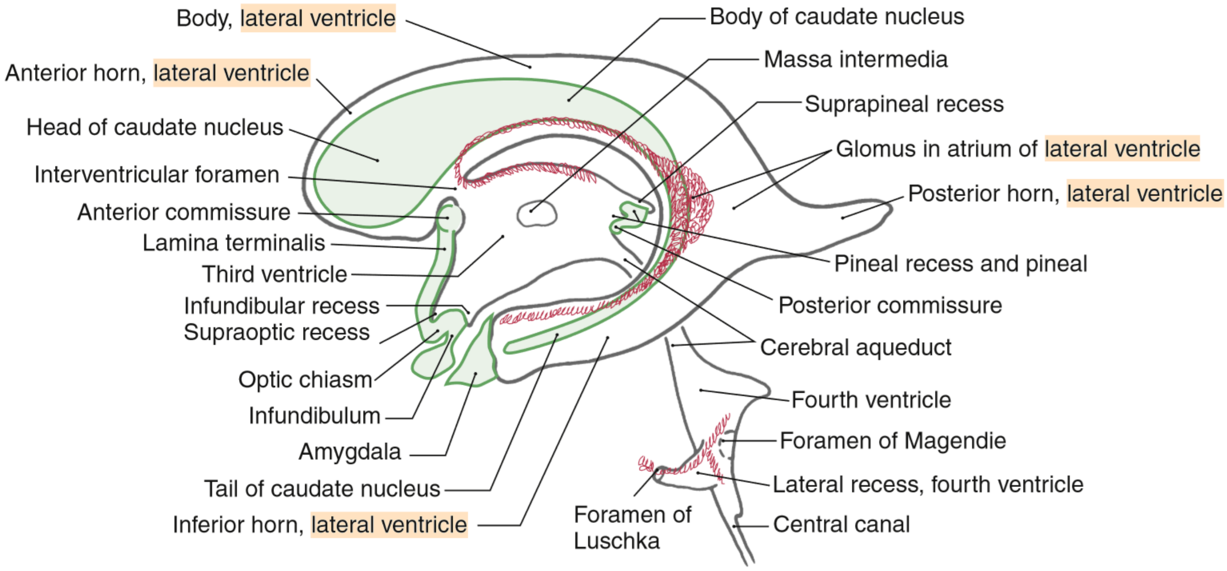
  2. Tenia Fornicis – on the medial side of the central part of the ventricle, adjacent to fornix. It continues to the inferior horn as Tenia Fimbriae, that attaches to the fimbria of hippocampus.

  3. The choroid plexus continues from the lateral ventricle into the 3rd ventricle through the interventricular foramina. In the third ventricle it is suspended from Tenia Thalami.

  4. The Glomus – clump of choroid plexus that is found in the atrium.

  **please notice – the choroid plexus is found only in the atrium, central and inferior parts of the lateral ventricle. The anterior and posterior parts have no choroid plexus.

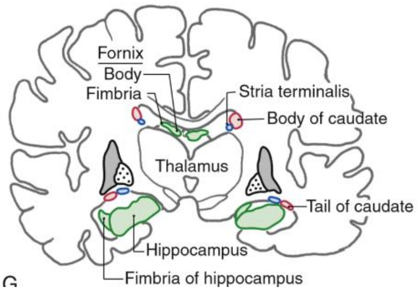

Tenia fornicis
Tenia choroidea
Tenia terminalis
Tenia fimbriae


Body, lateral ventricle
Anterior horn, lateral ventricle
Head of caudate nucleus
Interventricular foramen
Anterior commissure
Lamina terminalis
Third ventricle
Infundibular recess
Supraoptic recess
Optic chiasm
Infundibulum
Amygdala
Tail of caudate nucleus
Inferior horn, lateral ventricle
Foramen of Luschka
Body of caudate nucleus
Massa intermedia
Suprapineal recess
Glomus in atrium of lateral ventricle
Posterior horn, lateral ventricle
Pineal recess and pineal
Posterior commissure
Cerebral aqueduct
Fourth ventricle
Foramen of Magendie
Lateral recess, fourth ventricle
Central canal

Borders of the anterior horn and central part of lateral ventricle:

1. Anterior horn: → white matter , Anterior forceps

- Superiorly – Genu and Body of corpus callosum.
- Inferiorly – Rostrum of corpus callosum.
- Anteriorly – Genu of corpus callosum.
- Posteriorly – at the point of interventricular foramen, there it becomes the central part.
- Medially – Septum Pellucidum. seperates 2 ventricles
- Laterally – Head of Caudate nucleus.


Fornix
Body
Fimbria
Stria terminalis
Body of caudate
Thalamus
Tail of caudate
Hippocampus
Fimbria of hippocampus
G

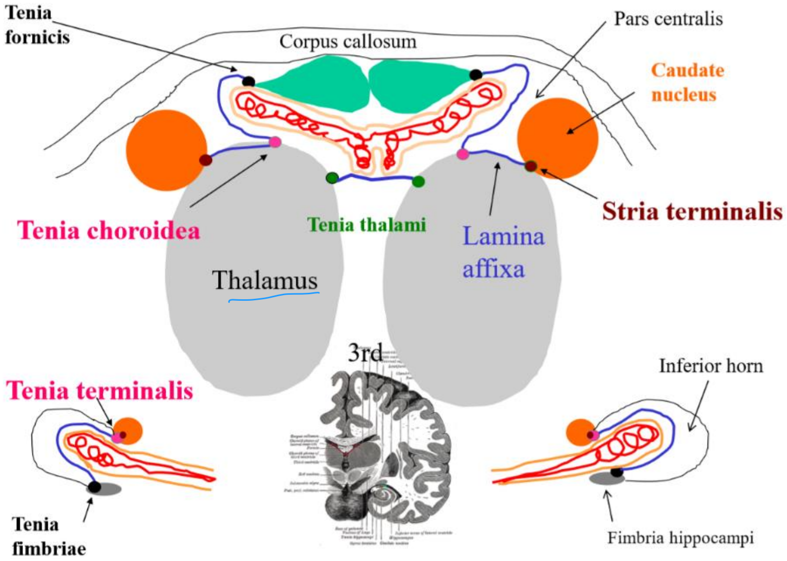
2. Central part (Body):

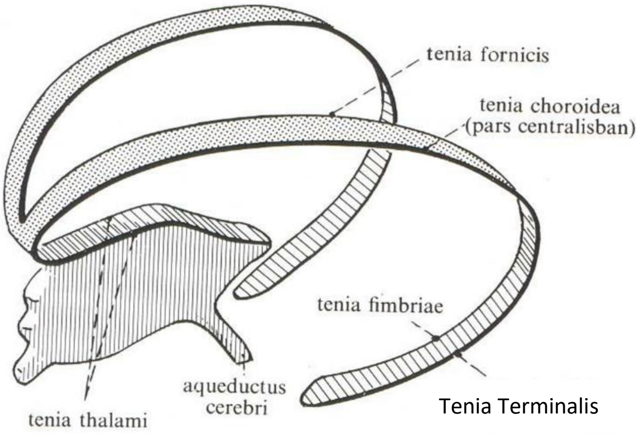
- Superiorly – body of corpus callosum.
- Inferiorly – thalamus, and on its surface few structures (medial to lateral):

lamina cells + attached to smth

  - Tenia Choroidea – attachment of the choroid plexus. CSF
  - Lamina Affixa Thalami – layer of epithelium on the surface of the Thalamus. Between Tenia Choroidea and Stria Terminalis.
  - Thalamostriate vein – also called terminal vein. Associated with Stria Terminalis.
  - Stria Terminalis – fibers between the amygdala and hypothalamus.
  - Body of caudate nucleus Is found laterally.
- Anteriorly – at the point of interventricular foramen, there it becomes the anterior horn.
- Posteriorly – descend into the Atrium.
- Medially – superiorly the corpus callosum, the fornix beneath. no septum Pellucidum (or maybe little of it at the front).
- Laterally – body of caudate nucleus. Next to it is the Stria Terminalis.

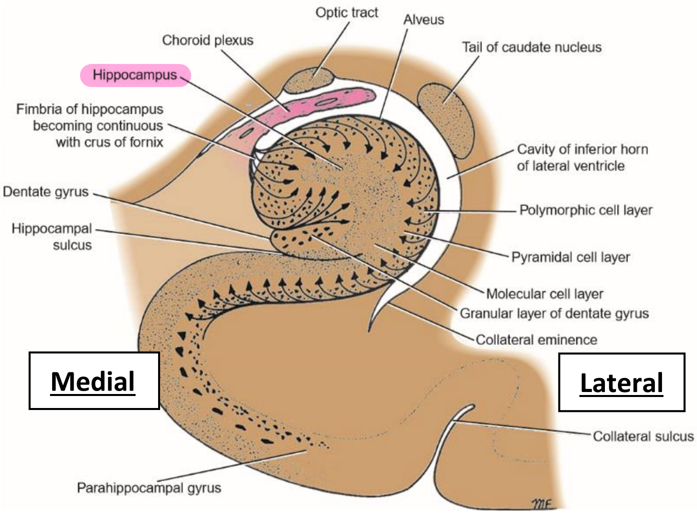
All 5 tenia can be seen on this lovely drawing of cross section from lecture that takes years to understand

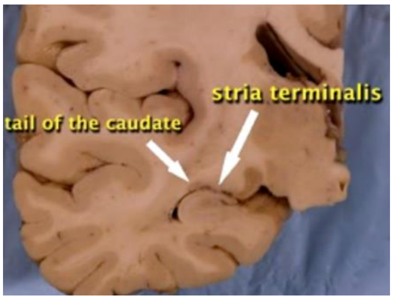

Tenia fornicis
Corpus callosum
Pars centralis
Caudate nucleus
Tenia choroidea
Tenia thalami
Lamina affixa
Stria terminalis
Thalamus
3rd
Tenia terminalis
Inferior horn
Tenia fimbriae
Fimbria hippocampi


tenia fornicis
tenia choroidea
(pars centralisban)
tenia fimbriae
aqueductus cerebri
tenia thalami
Tenia Terminalis

3. Inferior horn: in the temporal lobe.

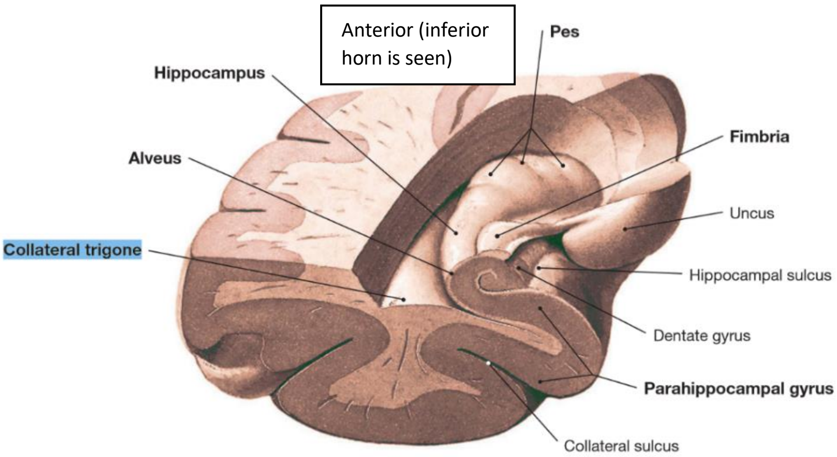
- Superiorly – tail of caudate.
- Inferiorly –
  1. hippocampus – Continue anteriorly to pes-hippocampi.
  2. Collateral eminence – inner reflection made by the collateral sulcus.
- Anteriorly – Amygdala, at the level of temporal pole.
- Posteriorly – continue into the Atrium of the lateral ventricle.
- Medially – fimbria of hippocampus. Continue as the crus of fornix and Covered by Tenia Fimbria – attachment point of the choroid plexus.
- Laterally – white mater.
- Choroid plexus of the inferior ventricle is suspended from Tenia Fimbriae and Tenia Terminalis.

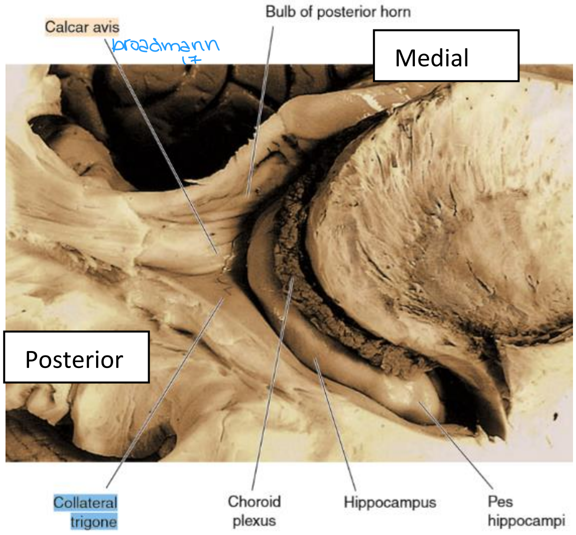

Optic tract
Alveus
Choroid plexus
Tail of caudate nucleus
Hippocampus
Fimbria of hippocampus becoming continuous with crus of fornix
Cavity of inferior horn of lateral ventricle
Dentate gyrus
Polymorphic cell layer
Hippocampal sulcus
Pyramidal cell layer
Molecular cell layer
Granular layer of dentate gyrus
Collateral eminence
Medial
Lateral
Collateral sulcus
Parahippocampal gyrus
MF


stria terminalis
tail of the caudate

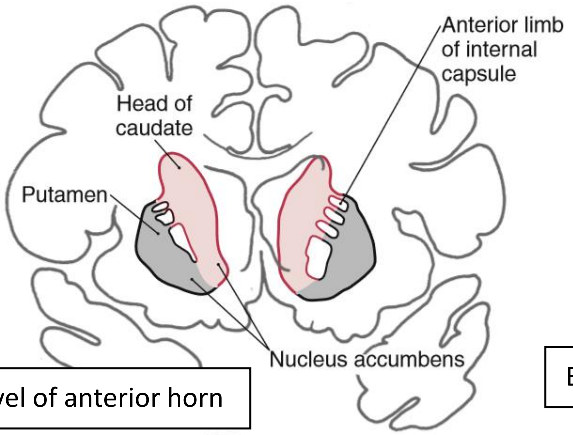
4. Posterior horn: in the occipital lobe.
generally surrounded by occipital white matter
(so use it if you can't remember all of the following):

- Superiorly – Tapetum, which is group of commissural fibers passing through corpus callosum.
- Inferiorly – white mater and the collateral trigone – the point of divergence of occipital and temporal horns from the central part.
- Anteriorly – continues into the atrium of the lateral ventricle.
- Posteriorly – white matter.
- Medially – Calcar Avis, an elevation made by the Calcarine sulcus.
- Laterally – Tapetum.

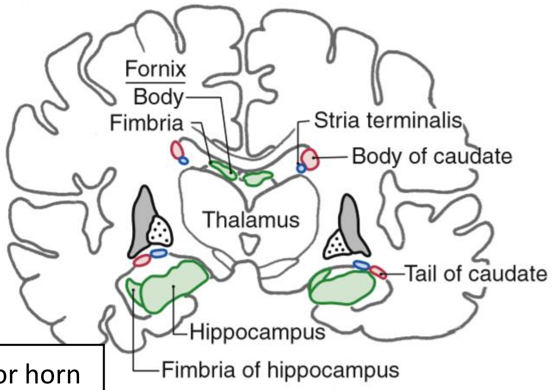

Anterior (inferior horn is seen)
Pes
Hippocampus
Fimbria
Alveus
Uncus
Collateral trigone
Hippocampal sulcus
Dentate gyrus
Parahippocampal gyrus
Collateral sulcus


Calcar avis
broadmann
17
Bulb of posterior horn
Medial
Posterior
Collateral trigone
Choroid plexus
Hippocampus
Pes hippocampi

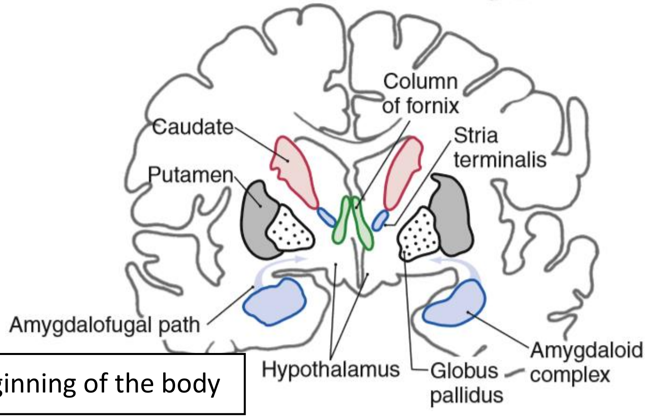
Cross sections and schemes


Anterior limb of internal capsule
Head of caudate
Putamen
Nucleus accumbens

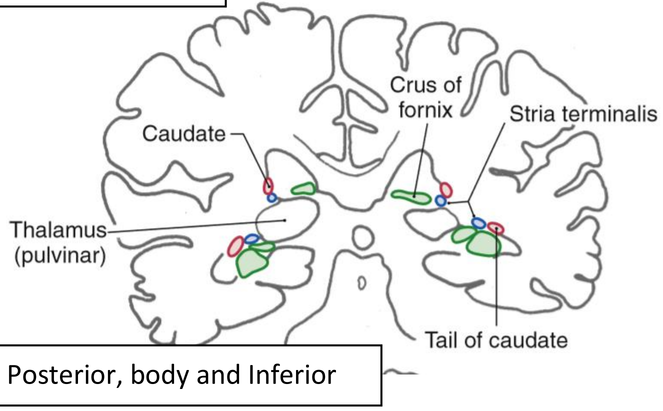
Level of anterior horn


Fornix
Body
Fimbria
Stria terminalis
Body of caudate
Thalamus
Tail of caudate
Hippocampus
Fimbria of hippocampus

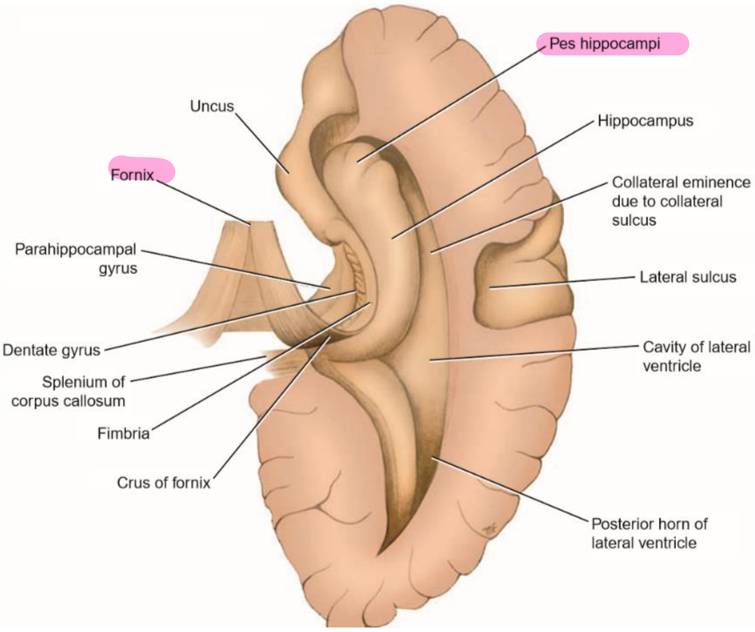
Body and Inferior horn

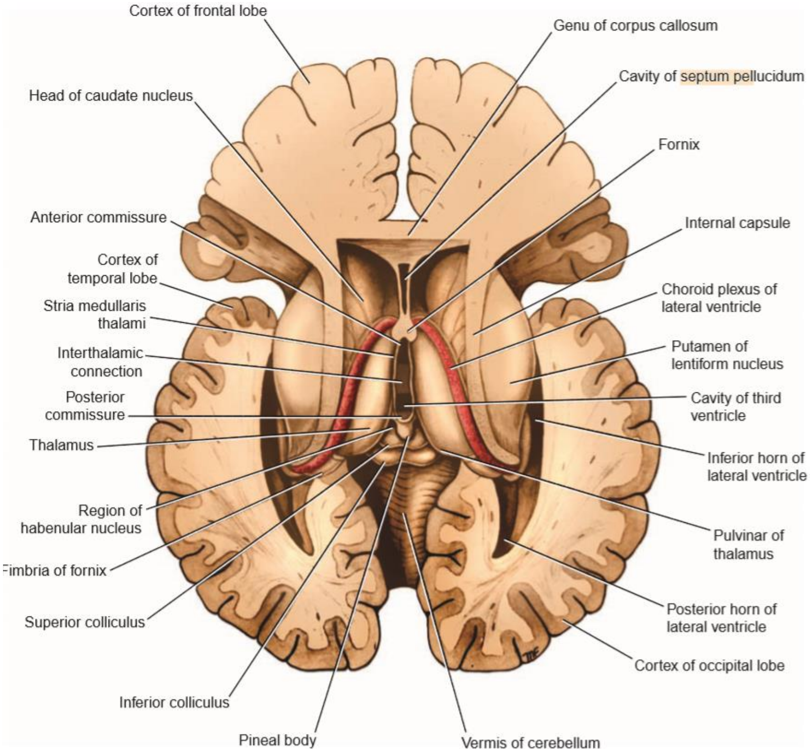

Column of fornix
Caudate
Stria terminalis
Putamen
Amygdalofugal path
Hypothalamus
Globus pallidus
Amygdaloid complex

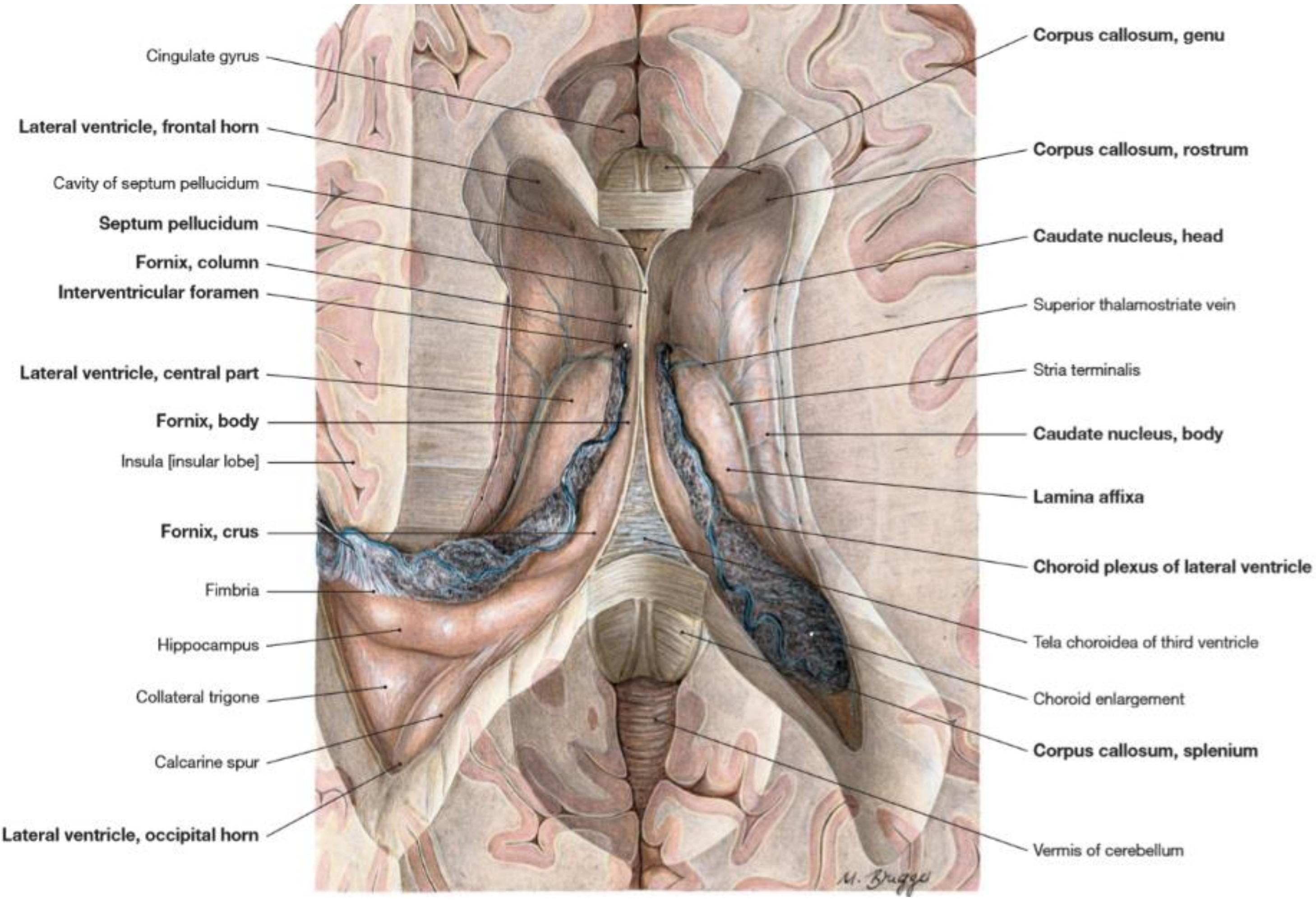
Beginning of the body

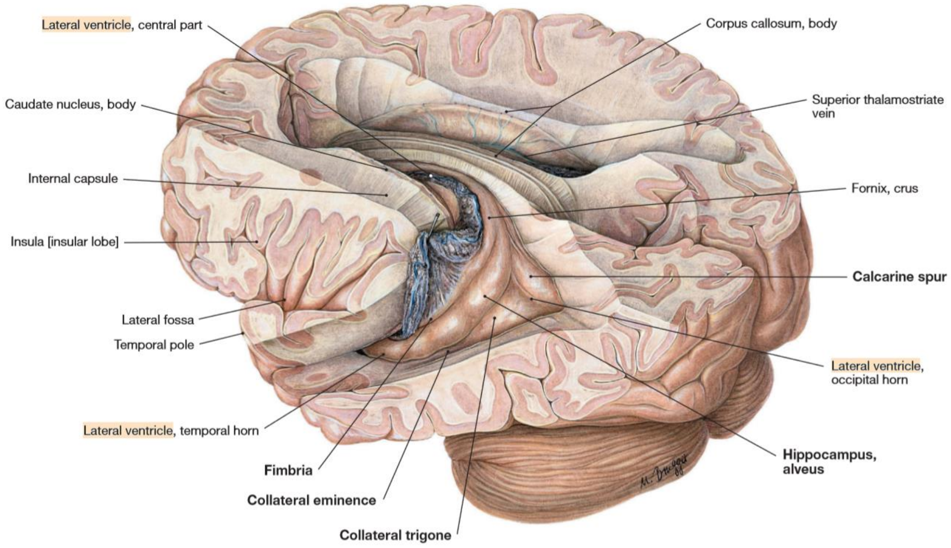

Crus of fornix
Caudate
Stria terminalis
Thalamus (pulvinar)
Tail of caudate

Posterior, body and Inferior


Pes hippocampi
Uncus
Hippocampus
Fornix
Collateral eminence due to collateral sulcus
Parahippocampal gyrus
Lateral sulcus
Dentate gyrus
Cavity of lateral ventricle
Splenium of corpus callosum
Fimbria
Crus of fornix
Posterior horn of lateral ventricle


Cortex of frontal lobe
Genu of corpus callosum
Cavity of septum pellucidum
Head of caudate nucleus
Fornix
Anterior commissure
Internal capsule
Cortex of temporal lobe
Choroid plexus of lateral ventricle
Stria medullaris thalami
Putamen of lentiform nucleus
Interthalamic connection
Cavity of third ventricle
Posterior commissure
Thalamus
Inferior horn of lateral ventricle
Region of habenular nucleus
Pulvinar of thalamus
Fimbria of fornix
Posterior horn of lateral ventricle
Superior colliculus
Cortex of occipital lobe
Inferior colliculus
Pineal body
Vermis of cerebellum


Cingulate gyrus
Lateral ventricle, frontal horn
Cavity of septum pellucidum
Septum pellucidum
Fornix, column
Interventricular foramen
Lateral ventricle, central part
Fornix, body
Insula [insular lobe]
Fornix, crus
Fimbria
Hippocampus
Collateral trigone
Calcarine spur
Lateral ventricle, occipital horn
Corpus callosum, genu
Corpus callosum, rostrum
Caudate nucleus, head
Superior thalamostriate vein
Stria terminalis
Caudate nucleus, body
Lamina affixa
Choroid plexus of lateral ventricle
Tela choroidea of third ventricle
Choroid enlargement
Corpus callosum, splenium
Vermis of cerebellum

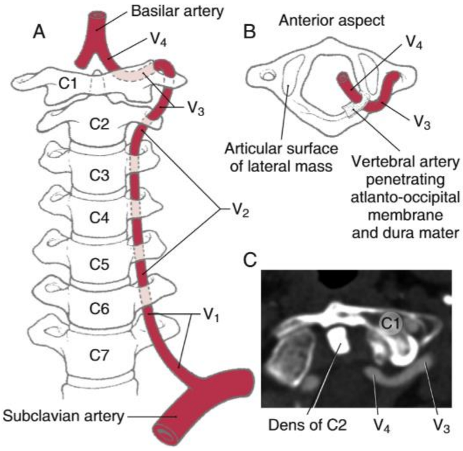

Lateral ventricle, central part
Caudate nucleus, body
Internal capsule
Insula [insular lobe]
Lateral fossa
Temporal pole
Lateral ventricle, temporal horn
Fimbria
Collateral eminence
Collateral trigone
Corpus callosum, body
Superior thalamostriate vein
Fornix, crus
Calcarine spur
Lateral ventricle, occipital horn
Hippocampus, alveus

Topic 20 – Blood supply of the central nervous system

Blood supply of the brain:

Hain's 109. This topic gives general explanation of the arteries. The structures they supply are mentioned in topics 16-18.

- Blood supply of the brain is based on 2 sources – vertebral artery and internal carotid artery.
- These 2 arteries form the Circle of Willis, that supplies part of the brain, and make anastomosis that allow alternative blood flow pathways, in case of occlusion.
- In addition, most of the brain stem and cerebellum are supplied directly from vertebral artery branches.



I. Vertebral artery:

- Forms the Vertebrobasilar system – main supplier of brain stem.
- Pathway: Has 4 parts – V1-V4.
  V1 – Originate from the subclavian arteries, 1 on each side, then it ascends through the neck.
  V2 – Ascends through the transverse foramen of vertebra C6-C2.
  V3 – Penetrates the Atlantooccipital membrane, pass through C1 transverse foramen.
  V4 – Enters the skull through the foramen magnum, crosses the dura and forms the basilar artery at the caudal part of pons. Supplies the anterolateral medulla.
- Branches:

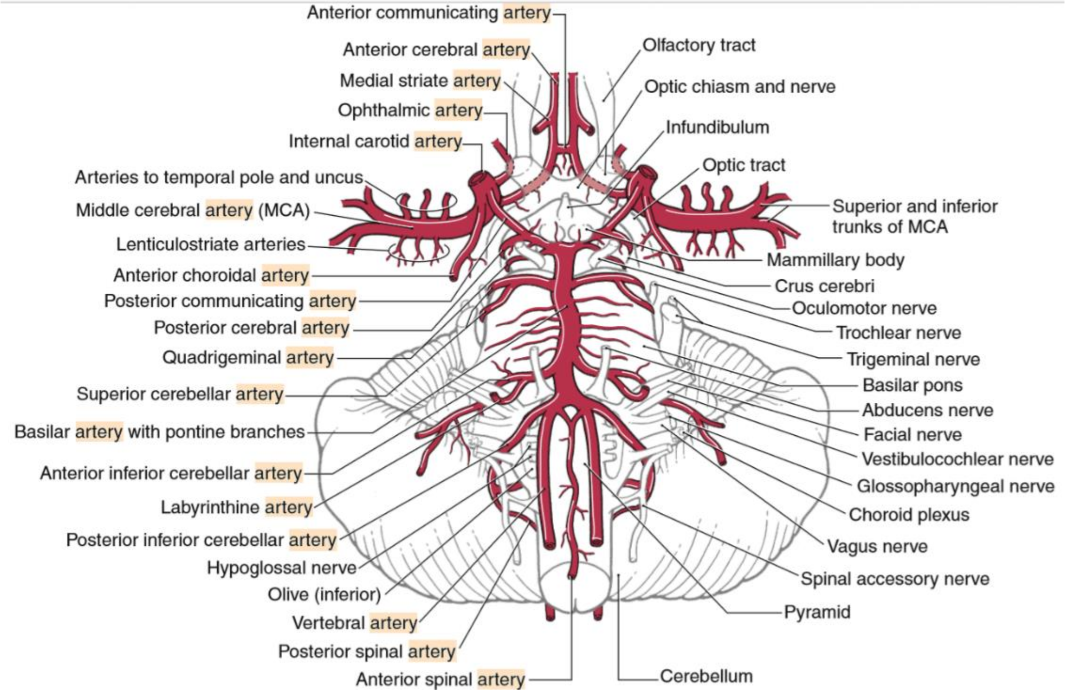
1. Posterior Inferior Cerebellar artery (PICA) – supplies the medulla and choroid plexus of 4th ventricle. Located in cisterna magna.
   a. Posterior spinal arteries – 2 arteries that descend to supply the posterior spinal cord, medulla and cerebellum. usually branch of PICA, less commonly originate from the vertebral artery.

2. Anterior Spinal artery – usually originates from 2 small trunks and unite to 1 at the foramen magnum. Travel in the ventral medial fissure of medulla and spinal cord. Found in premedullary cistern.

3. Basilar artery – formed by union of the 2 vertebral arteries at the level of caudal part of pons. it travels on the anterior brain stem, at the basilar sulcus on the pons, through the prepontine cistern. It gives the following branches:
   a. Anterior Inferior Cerebellar artery (AICA) – from the lower part of the artery, pass next to the middle cerebellar peduncle. Supplies the ventral and lateral cerebellum, pons and part of the choroid plexus of 4th ventricle.
      i. Labyrinthine artery – usually branch of AICA, can also come from the basilar artery. Enters the internal acoustic meatus to Supply the inner ear.
   b. Pontine arteries – many branches that supply the pons. penetrate into pons from different points (theoretical, not seen on the specimen) – First – Paramedian branches, then – short circumferential, lastly – long circumferential branches that surround the pons and enter posteriorly.

c. Superior cerebellar arteries (SCA) – last branch. Divides into medial and lateral branches, that supply the superior cerebellum, most cerebellar nuclei and midbrain.
pass under the oculomotor nerve.

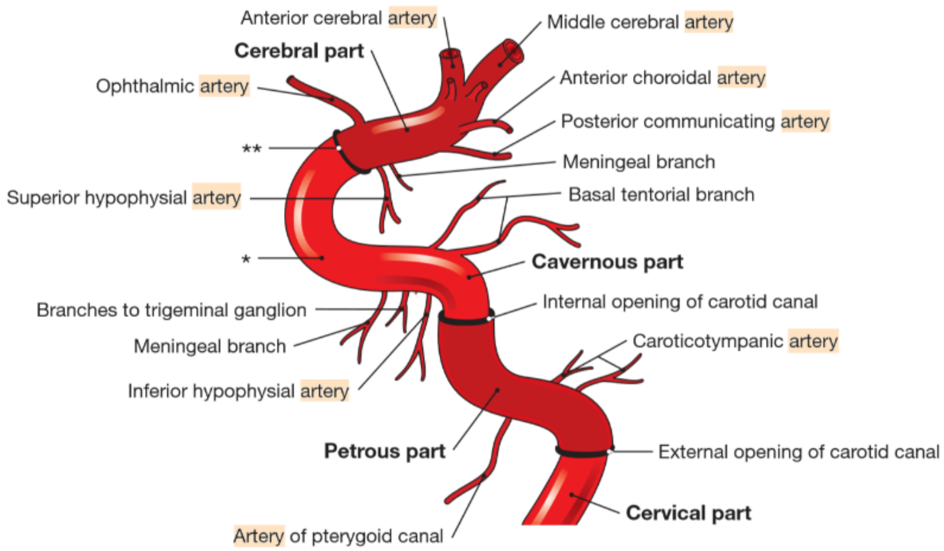
d. Posterior Cerebral artery – from the bifurcation of the basilar artery.
passes around the midbrain to the temporal lobe. Supplies the midbrain, Thalamus, ventral + medial surfaces of temporal and occipital lobes. Pass above the oculomotor nerve.
The posterior communicating artery connect it to ICA, as part of the circle of Willis.
parts of Posterior cerebral artery – divides into 4 segments, P1-P4:
P1 – between the basilar bifurcation to posterior communicating artery. Give the Quadrigeminal artery (supply the midbrain) and Perforating arteries (supply the Thalamus and other structures).
P2 – between the posterior communicating and the inferior temporal branch. Gives the medial and lateral posterior choroidal arteries.
P3 – give the temporal branches.
P4 – give the Parietooccipital and Calcarine branches.


Anterior communicating artery
Anterior cerebral artery
Medial striate artery
Ophthalmic artery
Internal carotid artery
Arteries to temporal pole and uncus
Middle cerebral artery (MCA)
Lenticulostriate arteries
Anterior choroidal artery
Posterior communicating artery
Posterior cerebral artery
Quadrigeminal artery
Superior cerebellar artery
Basilar artery with pontine branches
Anterior inferior cerebellar artery
Labyrinthine artery
Posterior inferior cerebellar artery
Hypoglossal nerve
Olive (inferior)
Vertebral artery
Posterior spinal artery
Anterior spinal artery
Olfactory tract
Optic chiasm and nerve
Infundibulum
Optic tract
Superior and inferior trunks of MCA
Mammillary body
Crus cerebri
Oculomotor nerve
Trochlear nerve
Trigeminal nerve
Basilar pons
Abducens nerve
Facial nerve
Vestibulocochlear nerve
Glossopharyngeal nerve
Choroid plexus
Vagus nerve
Spinal accessory nerve
Pyramid
Cerebellum

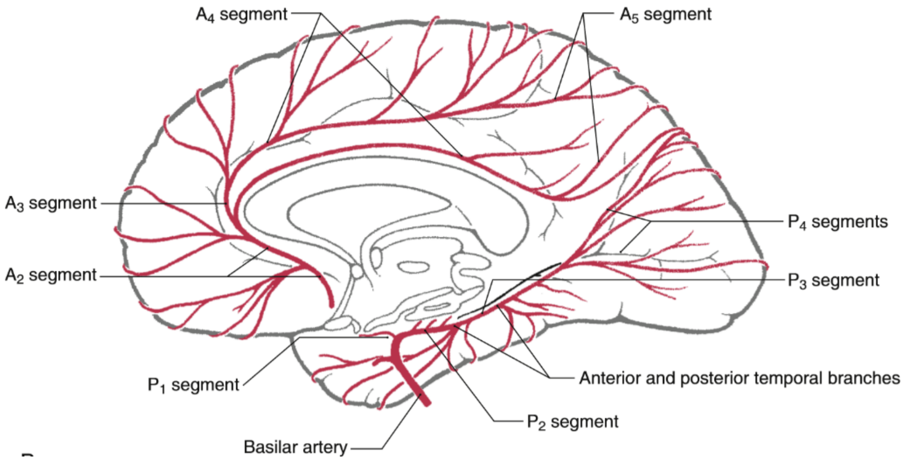
II. Internal carotid Artery (ICA):

- Has few parts:
  1. Cervical part – originates from common carotid (that comes from the aorta on the left and brachiocephalic trunk on the right). then it ascends in the neck up to the skull.
  2. Petrous part – enters the skull through the carotid canal, in the petrous part of the temporal bone. bend anteromedially.
  3. Cavernous part – exits the petrous bone and passes in the center of the Cavernous Sinus. Gives Inferior Hypophyseal and Meningeal arteries.
  4. Cerebral part – begins as it penetrates the dura, anterior to the optic nerve. Ends in dividing to anterior and middle cerebral arteries. Before this, it gives the following branches:
     a. Ophthalmic artery – pass through the optic foramen and gives central artery of retina.

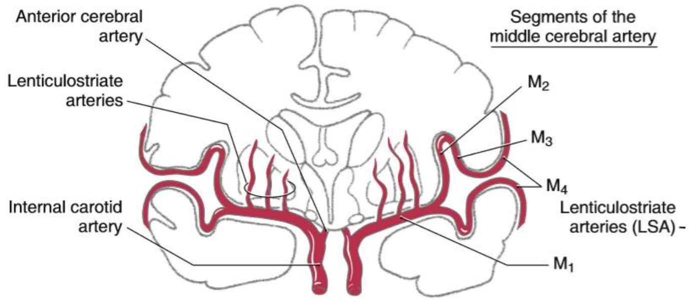
b. Anterior Choroidal artery – goes along the optic tract. Supply internal structures – Basal Ganglia, Hippocampus, Amygdala, Internal Capsule and Optic Tract.
c. Superior Hypophyseal artery – form the Hypothalamo-Hypophyseal portal system.
d. Posterior Communicating artery – connects it to the posterior cerebral artery, to form the Circle of Willis.
e. Then it gives the Anterior and Middle cerebral arteries, that supply the hemispheres. Their branches are generally named according to the area they supply.


Anterior cerebral artery
Cerebral part
Ophthalmic artery
**
Superior hypophysial artery
*
Branches to trigeminal ganglion
Meningeal branch
Inferior hypophysial artery
Petrous part
Artery of pterygoid canal
Middle cerebral artery
Anterior choroidal artery
Posterior communicating artery
Meningeal branch
Basal tentorial branch
Cavernous part
Internal opening of carotid canal
Caroticotympanic artery
External opening of carotid canal
Cervical part

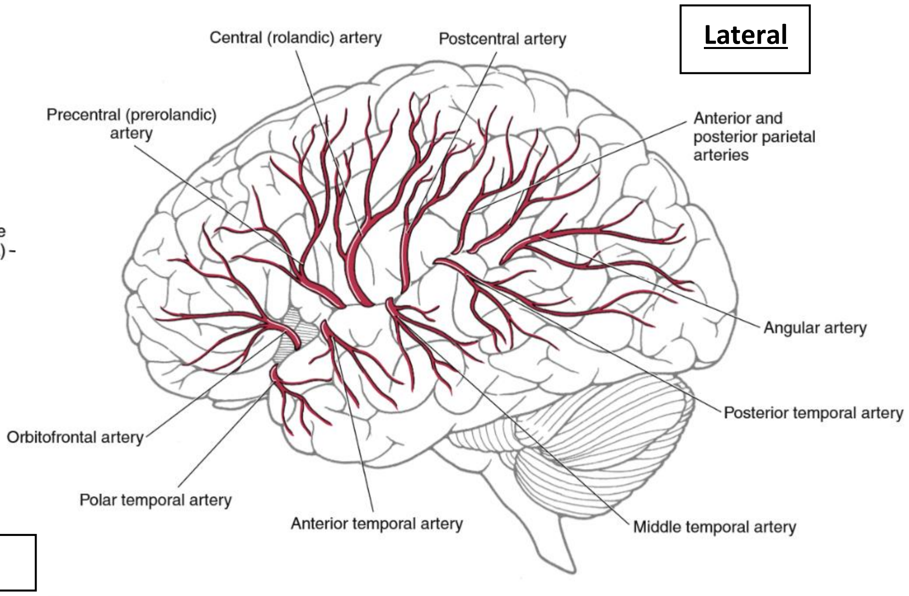
- Anterior cerebral artery (ACA) – supply mainly the medial surface.
  divide into 5 segments, A1-A5, named according to their position:
  A1 – Precommunicating segment. From ICA to anterior communicating artery.
  Go anteriorly, above the optic chiasm. Connect the other side by the communicating artery.
  A2 – Infracallosal segment. From anterior communicating to genu of corpus callosum.
  Supply the orbital gyri (Orbitofrontal a.) and frontal pole (Frontopolar a.).
  A3 – Precallosal segment – pass in front of the genu. **in the department they call it Pericallosal.
  Give Calloso-marginal artery and internal frontal branches.
  A4 – Supracallosal segment – pass above the corpus callosum.
  Supply the medial part of hemisphere.
  A5 – Postcallosal segmet – found posterior to the corpus callosum, at the parietooccipital sulcus.
  Supply the medial part of hemisphere.


A_4 segment
A_5 segment
A_3 segment
A_2 segment
P_4 segments
P_3 segment
P_1 segment
Anterior and posterior temporal branches
P_2 segment
Basilar artery

- Middle Cerebral artery (MCA) – usually larger than ACA. Supply mostly the lateral surface.
  Divide into 4 segments, M1-M4:
  M1 – from the ICA to the insula. Located in the subarachnoid space of the lateral fissure.
  Usually bifurcates to superior and anterior trunks. Supply the temporal lobe, and
  Gives the Lenticulostriate artery – supply structures in the hemispheres (basal ganglia).
  M2 – insular part – gives branches to insula.
  M3 – Opercular part – supply parts of frontal, temporal and parietal lobes that cover the insula.
  M4 – cortical part – exit the lateral fissure, supply the areas of lateral hemispheres.

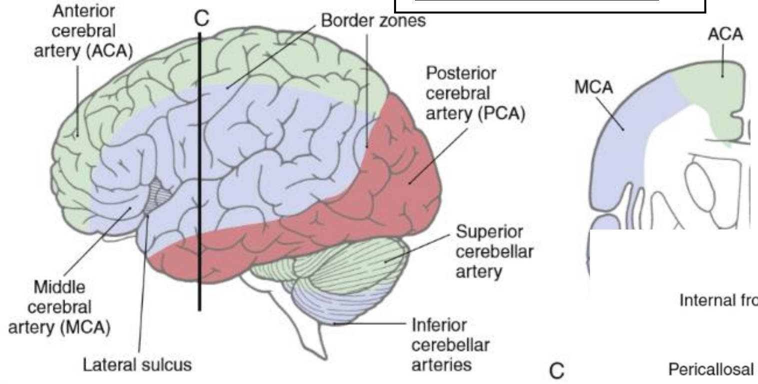

Anterior cerebral artery
Segments of the middle cerebral artery
Lenticulostriate arteries
M$_2$
M$_3$
M$_4$
Internal carotid artery
Lenticulostriate arteries (LSA) -
M$_1$

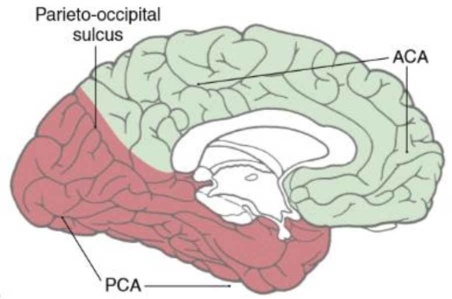
Lateral


Central (rolandic) artery
Postcentral artery
Precentral (prerolandic) artery
Anterior and posterior parietal arteries
Angular artery
Posterior temporal artery
Orbitofrontal artery
Polar temporal artery
Anterior temporal artery
Middle temporal artery

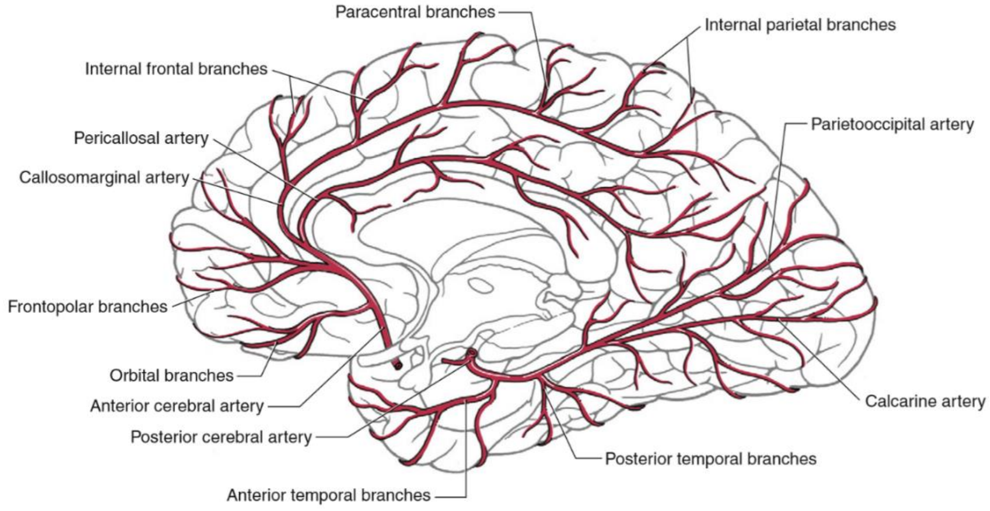
**Anterior, middle and posterior cerebral arteries supply the hemisphers as shown in the picture. Border zone is the area between their branches. It is more sensitive too lack of oxygen.

The most important


Anterior cerebral artery (ACA)
C
Border zones
Posterior cerebral artery (PCA)
Superior cerebellar artery
Middle cerebral artery (MCA)
Lateral sulcus
Inferior cerebellar arteries
ACA
MCA
C

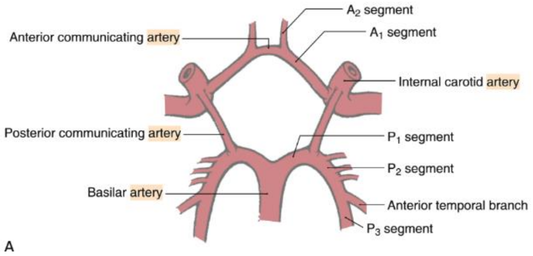

Parieto-occipital sulcus
ACA
PCA

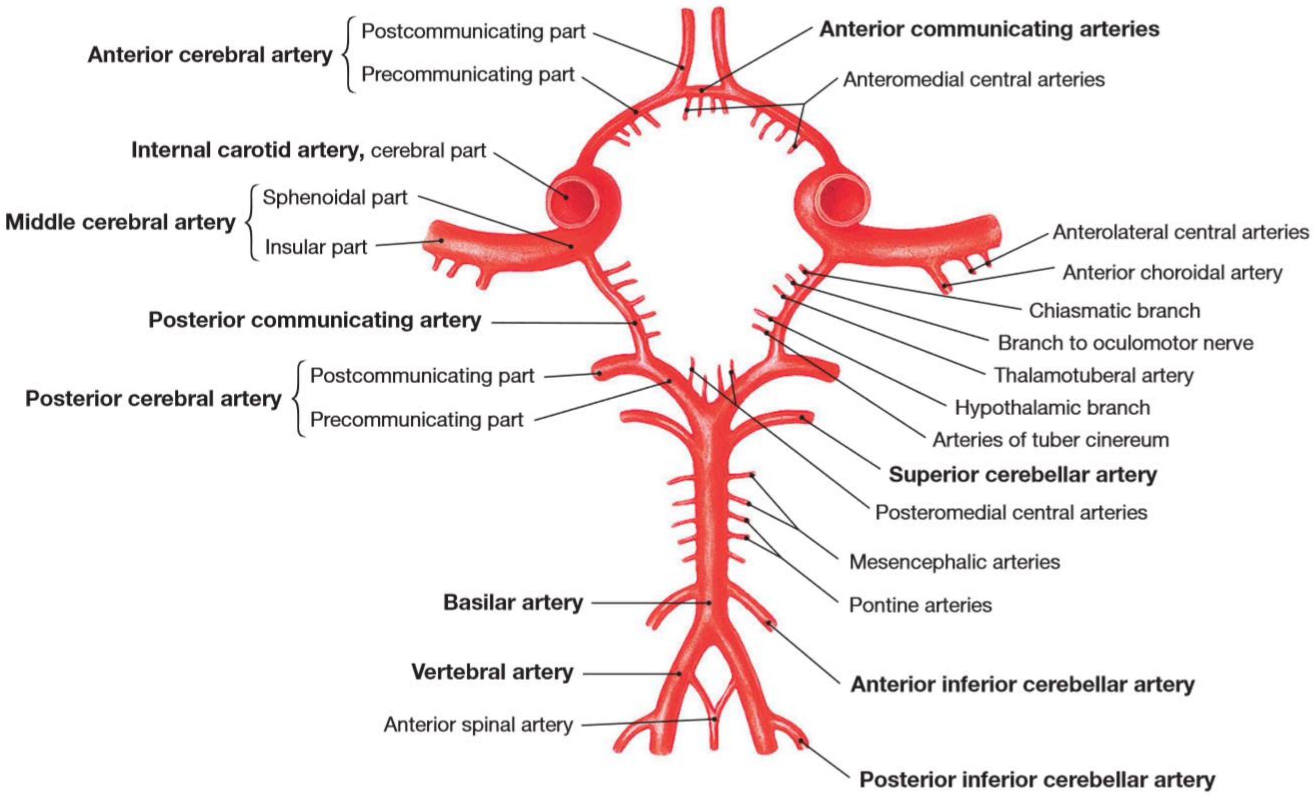
Medial view – anterior and posterior cerebral arteries


Paracentral branches
Internal parietal branches
Internal frontal branches
Parietooccipital artery
Pericallosal artery
Callosomarginal artery
Frontopolar branches
Orbital branches
Anterior cerebral artery
Posterior cerebral artery
Calcarine artery
Posterior temporal branches
Anterior temporal branches

Circle of Willis:

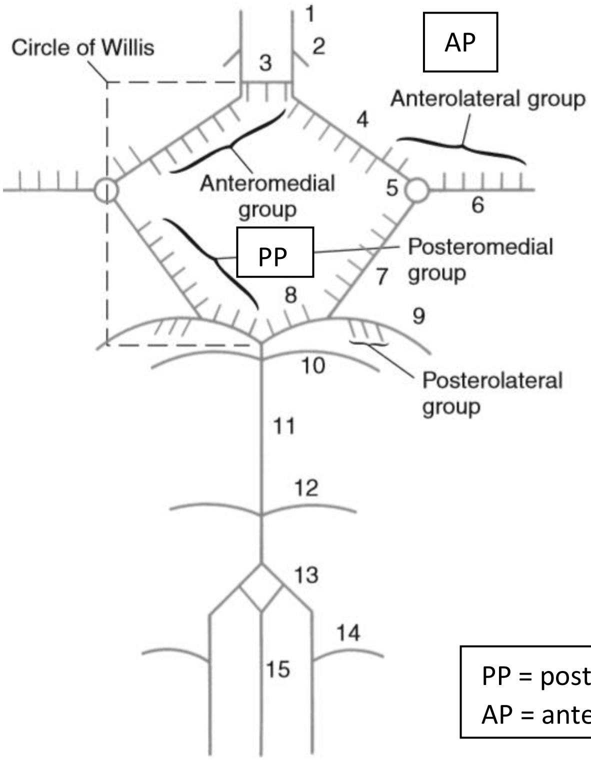
- A kind of heptagon (7 edges) on the inferior surface of the brain.
- It encircles few structures –
  1. Optic chiasm and tract.
  2. Hypothalamus, and beneath it the Infundibulum and Tuber Cinereum.
  3. Mammillary bodies.
  5. Structures of interpeduncular fossa.
- The circle enables anastomosis between the vertebral and internal carotid systems.
  in case of occlusion, or unequal pressure at a certain region, the circle provides alternative passage of blood.
- The arteries that form the circle –
  1. At the back – posterior cerebral arteries.
  2. Postero-lateral – Posterior communicating arteries – connect the posterior cerebral arteries to the ICA.
  3. Antero-laterally – Anterior cerebral arteries, from the ICA.
  4. Anteriorly – the anterior communicating artery, between the 2 Anterior cerebral arteries.


A
A_2 segment
Anterior communicating artery
A_1 segment
Internal carotid artery
Posterior communicating artery
P_1 segment
P_2 segment
Basilar artery
Anterior temporal branch
P_3 segment
A


Anterior cerebral artery
Postcommunicating part
Precommunicating part
Anterior communicating arteries
Anteromedial central arteries
Internal carotid artery, cerebral part
Middle cerebral artery
Sphenoidal part
Insular part
Anterolateral central arteries
Anterior choroidal artery
Chiasmatic branch
Branch to oculomotor nerve
Posterior communicating artery
Thalamotuberal artery
Posterior cerebral artery
Postcommunicating part
Precommunicating part
Hypothalamic branch
Arteries of tuber cinereum
Superior cerebellar artery
Posteromedial central arteries
Mesencephalic arteries
Basilar artery
Pontine arteries
Vertebral artery
Anterior inferior cerebellar artery
Anterior spinal artery
Posterior inferior cerebellar artery

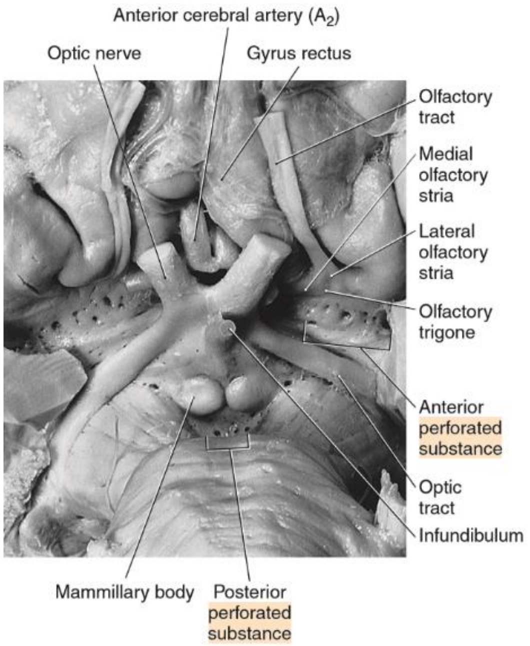
Central arteries:

- The arteries of the Circle of Willis give 4 groups of central arteries, also called perforating or ganglionic branches. These arteries supply structures deep in the brain. These groups of vessels are not really seen because they are very small, but you should understand the concept.
  The groups are:
  1. Anteromedial group – arise from A1 and anterior communicating artery.
     Serves the area of optic chiasm and anterior Hypothalamus.
  2. Anterolateral group – arise from A1 and M1. Gives Lenticulostriate arteries that Supply structures inside the hemispheres.
     Enter the hemisphere through the anterior perforated substance – area behind the Olfactory Tract that has many tiny holes, due to the arteries that penetrate it.
  3. Posteromedial group – arise from P1 and Posterior communicating artery.
     Supply the Crus Cerebri and Hypothalamus.
     Enter the interpeduncular fossa through the posterior perforated substance – area in the interpeduncular fossa that has many tiny holes, due to the arteries that penetrate it.
     give the Thalamoperforating arteries that supply the thalamus.
  4. Posterolateral group – arise from P2. Give the Thalamogeniculate artery (for the Thalamus) and Posterior Choroidal arteries (medial and lateral, supply the choroid plexus).


Circle of Willis
1
2
3
AP
4
Anterolateral group
Anteromedial group
5
6
PP
Posteromedial group
7
8
9
10
Posterolateral group
11
12
13
14
15

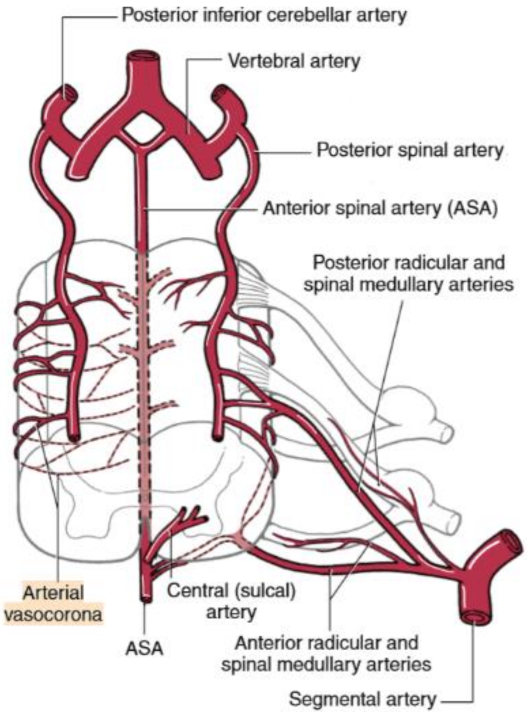
1 = Anterior cerebral a. (A_2)
2 = Medial striate a.
3 = Anterior communicating a.
4 = Anterior cerebral a. (A_1)
5 = Internal carotid a.
6 = Middle cerebral a. (M_1)
7 = Posterior communicating a.
8 = Posterior cerebral a. (P_1)
9 = Posterior cerebral a. (P_2)
10 = Superior cerebellar a.
11 = Basilar a.
12 = Anterior inferior cerebellar a.
13 = Vertebral a.
14 = Posterior inferior cerebellar a.
15 = Anterior spinal a.

PP = posterior perforated substance
AP = anterior perforated substance


Anterior cerebral artery (A2)
Optic nerve
Gyrus rectus
Olfactory tract
Medial olfactory stria
Lateral olfactory stria
Olfactory trigone
Anterior perforated substance
Optic tract
Infundibulum
Mammillary body
Posterior perforated substance

Blood supply of the Spinal Cord:
Hain's 116

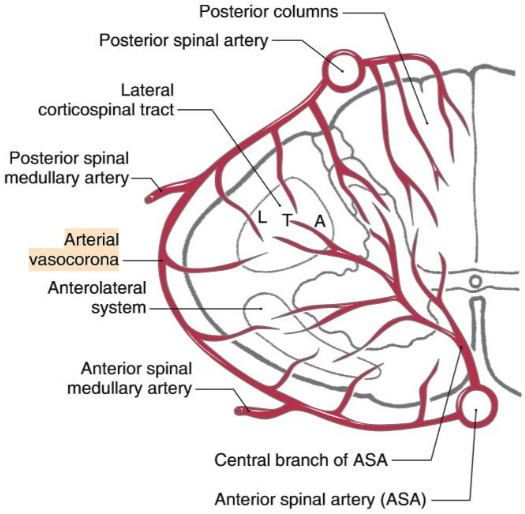
- Based on the anterior and posterior spinal arteries. Assisted by segmental arteries:



Posterior inferior cerebellar artery
Vertebral artery
Posterior spinal artery
Anterior spinal artery (ASA)
Posterior radicular and spinal medullary arteries
Arterial vasocorona
Central (sulcal) artery
ASA
Anterior radicular and spinal medullary arteries
Segmental artery

    1. Anterior spinal artery – 1 artery that pass in the Anterior Spinal Fissure. originates from the 2 small branches, one from each vertebral artery, and unite at the level of foramen magnum.
       gives central branches that serve the central region of the cord – Most of the gray matter and inner white matter.
    2. Posterior spinal arteries – 2 arteries that pass medial to the posterior root.
       Originate from the Posterior Inferior Cerebellar arteries (PICA, 1 on each side), OR from the Vertebral arteries.
       Supply the outer parts of the cord – including posterior columns, peripheral parts of the lateral and anterior funiculi. Outer parts are also supplied by Arterial Vasocorona.
       It supplies sufficiently only the cervical region. Inferior to it the segmental branches assist.
    3. Segmental arteries – assist in supplying the cord, because the spinal arteries are not strong enough to supply the whole spinal cord.
       originate from different arteries, according to the level, that give spinal branches:
        - Cervical region – Vertebral artery.
        - Thoracic region – Posterior Intercostal arteries.
        - Lumbar region – Abdominal aorta (Barr's).

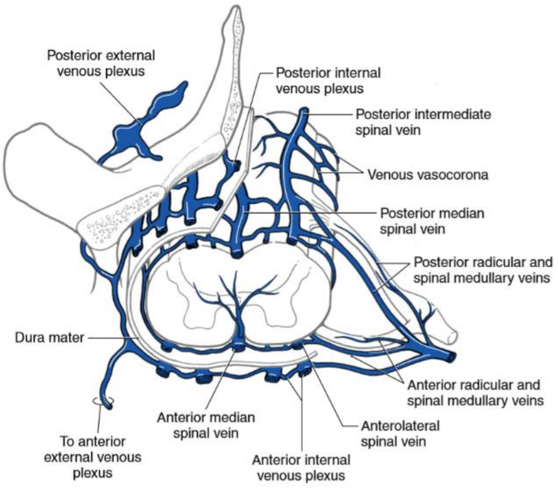
       Segmental arteries give their spinal branches that enter through the intervertebral foramina and divide into Anterior and Posterior Redicular arteries, and Spinal Medullary arteries:
        - ✈ Redicular arteries – supply the posterior and anterior roots, and the Posterior root ganglia.
        - ✈ spinal medullary arteries – supply the cord:
            - ✓ Arterial Vasocorona – arterial network, formed by the terminal branches of the spinal medullary arteries.
            - ✓ Great anterior medullary Artery of **Adamkiewicz** – at the level of T12 to L2. big branches of the spinal medullary arteries. They are only in 1 side, usually left.



Posterior columns
Posterior spinal artery
Lateral corticospinal tract
Posterior spinal medullary artery
L
T
A
Arterial vasocorona
Anterolateral system
Anterior spinal medullary artery
Central branch of ASA
Anterior spinal artery (ASA)

Venous drainage – Basically similar to the arteries:

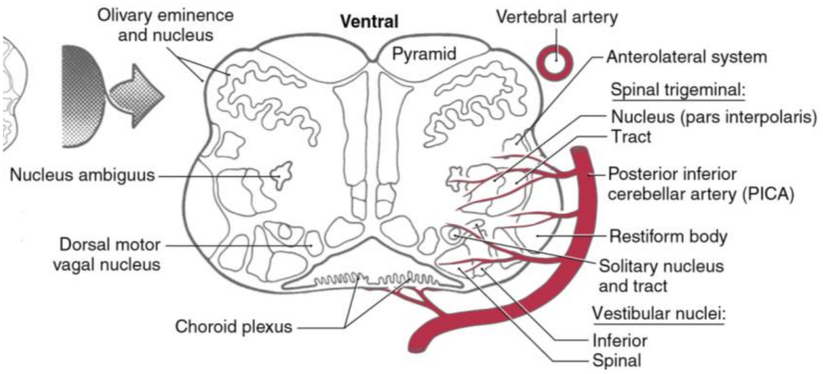
- Anterior and posterior spinal veins, form the internal and external venous plexuses. Exit through the intervertebral vein.


Posterior external venous plexus
Posterior internal venous plexus
Posterior intermediate spinal vein
Venous vasocorona
Posterior median spinal vein
Posterior radicular and spinal medullary veins
Dura mater
Anterior radicular and spinal medullary veins
Anterolateral spinal vein
Anterior median spinal vein
To anterior external venous plexus
Anterior internal venous plexus

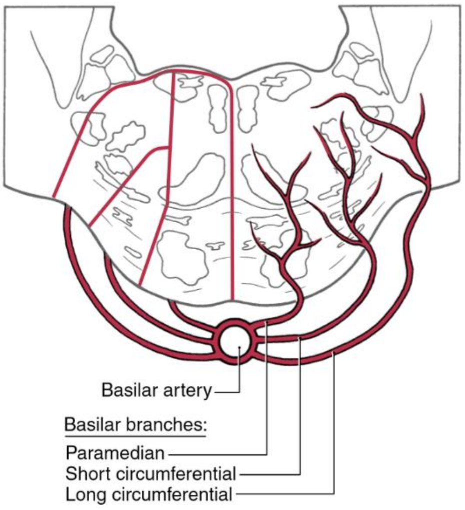
Blood supply of the Brain stem:

**Notice – on the specimen you can only see the big vessels. The others are small and cannot be seen.

- Medulla (Hain's 156): supplied by branches of the vertebral arteries – Anterior Spinal artery and PICA.
    1. Inner structures – Anterior Spinal artery.
    2. Posterior medulla caudal to obex – Posterior Spinal artery. Including the gracile and cuneate and spinal trigeminal nuclei.
    3. Posterior medulla rostral to obex – Posterior Inferior Cerebellar artery (PICA). Including anterolateral system, solitary tract and nucleus Ambiguus.
    4. Pons Medullary junction – Anterior Inferior Cerebellar artery (AICA).

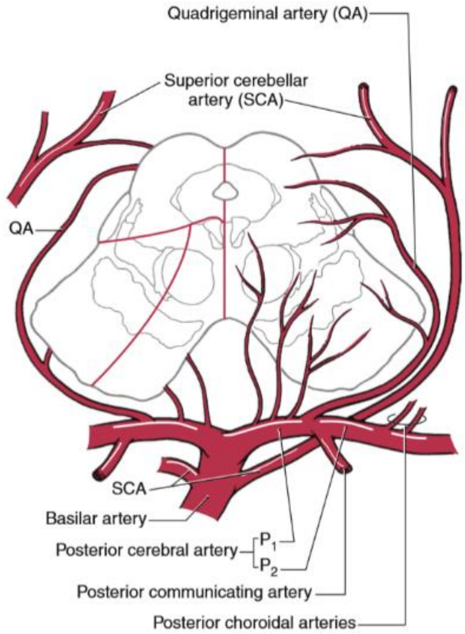

Olivary eminence and nucleus
Ventral
Pyramid
Vertebral artery
Anterolateral system
Spinal trigeminal:
Nucleus (pars interpolaris)
Tract
Nucleus ambiguus
Posterior inferior cerebellar artery (PICA)
Restiform body
Dorsal motor vagal nucleus
Solitary nucleus and tract
Vestibular nuclei:
Choroid plexus
Inferior
Spinal

- Pons (Hain's 165):
  Supplied by pontine arteries from the basilar artery. These arteries give branches:
    1. Paramedian branches – enter directly after branching, supply the medial area of basilar pons.
    2. Short circumferential branches – surround the pons for short distance, supply the lateral parts.
    3. Long circumferential branches – surround the pons for long distance, supply the tegmentum and part of the middle cerebellar peduncle.
    4. AICA – supply the Pons Medullary junction.
    5. Superior cerebellar artery – supply the superior part of pons.

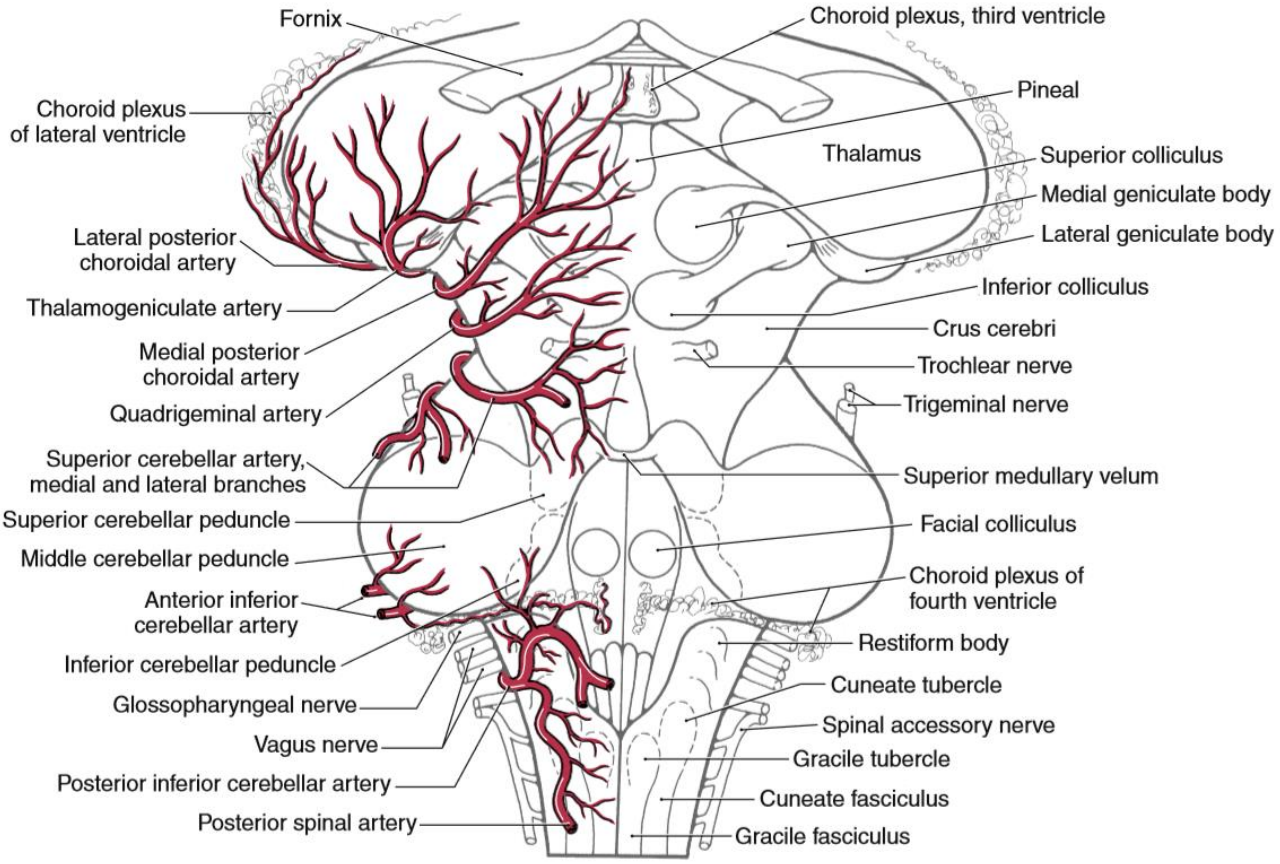

Basilar artery
Basilar branches:
Paramedian
Short circumferential
Long circumferential

- Midbrain (Hain’s 178): supplied mainly by branches of basilar arteries (superior cerebellar and posterior cerebral arteries). If you want to know too much:
    1. Quadrigeminal artery – originates from P1.
       Supplies the ventrolateral region – lateral crus cerebri, substantia nigra and medial lemniscus. Also supply the posterior region, including inferior colliculi and periaqueductal gray.
    2. Superior cerebellar arteries – supply the posterior region.
    3. Anterior choroidal artery – branch of ICA. supply the ventrolateral region.
    4. Medial posterior choroidal artery – branch of posterior cerebral artery (P2). supplies the ventrolateral region.
    5. Paramedian branches – from P1 and posterior communicating artery. Supply the anterior region. They form the posteromedial group of the Circle of Willis.

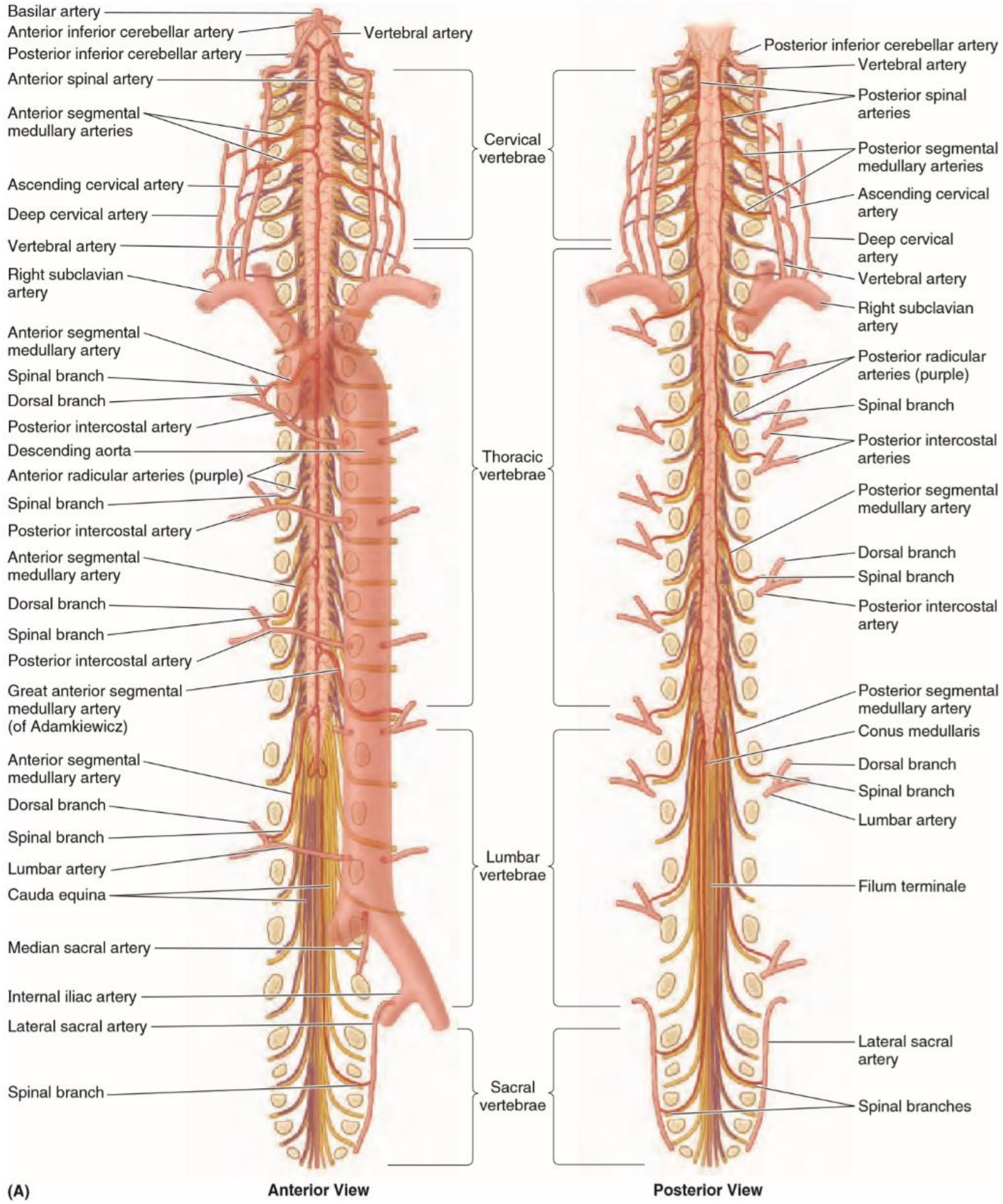
“quadrigeminal” – to “quadrigeminal body” = the 4 colliculi.


Quadrigeminal artery (QA)
Superior cerebellar artery (SCA)
QA
SCA
Basilar artery
Posterior cerebral artery
P_1
P_2
Posterior communicating artery
Posterior choroidal arteries

Posterior view of brain stem


Fornix
Choroid plexus, third ventricle
Choroid plexus of lateral ventricle
Pineal
Thalamus
Superior colliculus
Medial geniculate body
Lateral geniculate body
Lateral posterior choroidal artery
Thalamogeniculate artery
Inferior colliculus
Medial posterior choroidal artery
Crus cerebri
Trochlear nerve
Quadrigeminal artery
Trigeminal nerve
Superior cerebellar artery, medial and lateral branches
Superior medullary velum
Superior cerebellar peduncle
Facial colliculus
Middle cerebellar peduncle
Choroid plexus of fourth ventricle
Anterior inferior cerebellar artery
Restiform body
Inferior cerebellar peduncle
Cuneate tubercle
Glossopharyngeal nerve
Spinal accessory nerve
Vagus nerve
Gracile tubercle
Posterior inferior cerebellar artery
Cuneate fasciculus
Posterior spinal artery
Gracile fasciculus

Anterior **Posterior**


Basilar artery
Anterior inferior cerebellar artery
Posterior inferior cerebellar artery
Anterior spinal artery
Anterior segmental medullary arteries
Ascending cervical artery
Deep cervical artery
Vertebral artery
Right subclavian artery
Anterior segmental medullary artery
Spinal branch
Dorsal branch
Posterior intercostal artery
Descending aorta
Anterior radicular arteries (purple)
Spinal branch
Posterior intercostal artery
Anterior segmental medullary artery
Dorsal branch
Spinal branch
Posterior intercostal artery
Great anterior segmental medullary artery (of Adamkiewicz)
Anterior segmental medullary artery
Dorsal branch
Spinal branch
Lumbar artery
Cauda equina
Median sacral artery
Internal iliac artery
Lateral sacral artery
Spinal branch
Vertebral artery
Cervical vertebrae
Thoracic vertebrae
Lumbar vertebrae
Sacral vertebrae
Posterior inferior cerebellar artery
Vertebral artery
Posterior spinal arteries
Posterior segmental medullary arteries
Ascending cervical artery
Deep cervical artery
Vertebral artery
Right subclavian artery
Posterior radicular arteries (purple)
Spinal branch
Posterior intercostal arteries
Posterior segmental medullary artery
Dorsal branch
Spinal branch
Posterior intercostal artery
Posterior segmental medullary artery
Conus medullaris
Dorsal branch
Spinal branch
Lumbar artery
Filum terminale
Lateral sacral artery
Spinal branches
(A)
Anterior View
Posterior View

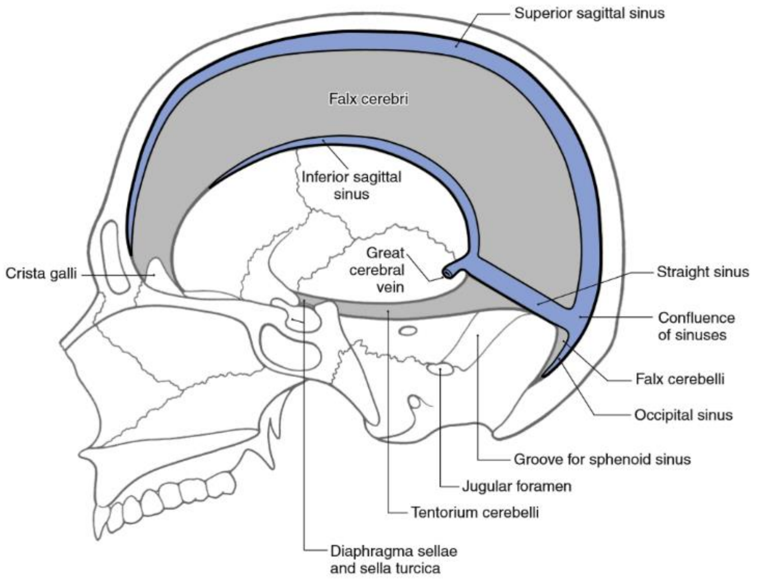
Topic 21 – Meninges of the Brain. Blood supply and innervation of the Dura mater. Structures in the spaces between meninges. Characteristic types of bleeding. Major Cisterns

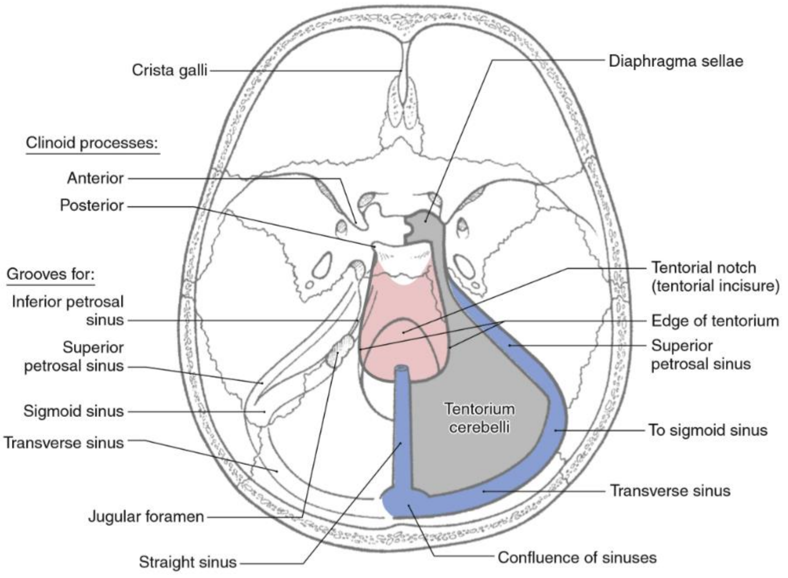
Hain's 95

- Meninges – forms continuous cover of the CNS.
- Located internal to skull and vertebral column.
- Function: protection, support blood vessels and enclose the subarachnoid that contain the CSF.
- Has 3 layers: Dura mater, Arachnoid mater and Pia mater.

Dura mater – outer layer. Also called Pachymeninx.

- Derived from mesenchyme.
- Has 2 layers –
  Outer: periosteal. Adheres the bones of the skull, mainly along the sutures. Doesn't adhere to the vertebra.
  Inner: meningeal.
- The inner Dural layer forms 4 septa (infoldings), that are associated with venous sinuses –
  1. Falx cerebri – between the right and left hemispheres. Attach crista galli anteriorly and Tentorium Cerebelli posteriorly. Separates the 2 hemispheres and forms few sinuses:
     - Superior sagittal sinus – where the Falx Cerebri binds the skull.
     - Inferior sagittal sinus – at the inferior free edge of Falx cerebri.
     - Strait sinus – at the connection of Falx cerebri and Tentorium Cerebelli.
  2. Tentorium Cerebelli – second largest septa. Attach the clinoid processes anteriorly, petrous part of temporal bone on the sides, and posteriorly to the occipital and parietal bone.
     it divides the cranial cavity to Supratentorial and Infratentorial (Occupied by cerebellum).
     Forms the tentorial notch in the middle, behind the clinoid processes.
     - Transverse sinus – formed at the connection to the occipital and parietal bones.
  3. Falx Cerebelli – small, located inferior to the Tentorium Cerebelli, between cerebellar hemispheres. Bind the internal occipital crest. Forms the occipital sinus.
  4. Diaphragm Sellae – forms the roof of Hypophyseal fossa and surrounds pituitary stalk. The diaphragm is surrounded by the cavernous sinus.


Superior sagittal sinus
Falx cerebri
Inferior sagittal sinus
Crista galli
Great cerebral vein
Straight sinus
Confluence of sinuses
Falx cerebelli
Occipital sinus
Groove for sphenoid sinus
Jugular foramen
Tentorium cerebelli
Diaphragma sellae and sella turcica


Crista galli
Diaphragma sellae
Clinoid processes:
Anterior
Posterior
Grooves for:
Inferior petrosal sinus
Superior petrosal sinus
Sigmoid sinus
Transverse sinus
Jugular foramen
Straight sinus
Tentorial notch (tentorial incisure)
Edge of tentorium
Superior petrosal sinus
Tentorium cerebelli
To sigmoid sinus
Transverse sinus
Confluence of sinuses

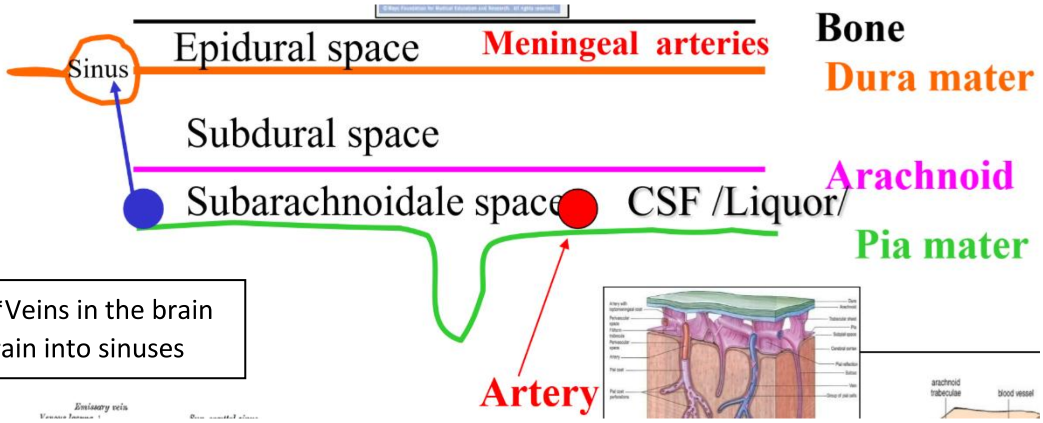
- All nerves and vessels that enter or exit the CNS, must pass through the dura. The dura is continuous with the CT of peripheral nerves.
- The dura is attached to the foramen magnum. Caudally the dura ends in the level of S2 as the Filum Terminale Externum, also called Dural part of the Filum Terminale or Coccygeal Ligament.

- Blood supply and innervation –
  Meningeal arteries supply the dura together with other arteries. They arise from external carotid artery, and run in the Epidural space.
  - ✈ In the Anterior Cranial fossa –
    1. cavernous part of ICA,
    2. Anterior meningeal artery (branch of the ethmoidal arteries).
       Nerve – Branches of trigeminal nerve (Maxillary and Mandibular) + Ethmoidal nerves.
  - ✈ In the Middle Cranial fossa –
    1. Middle Meningeal artery (foramen Spinosum, branch of Maxillary artery).
    2. Accessory Meningeal (foramen ovale, branch of Mandibular artery).
       Nerve – Branches of trigeminal nerve (Maxillary and Mandibular).
  - ✈ In the Posterior cranial fossa –
    1. Branches of Ascending Pharyngeal and Occipital arteries (both from the External Carotid).
    2. Branches of Vertebral arteries.
       Nerve – dorsal roots of C2-C3, and the vagus. Tentorial nerve to the Tentorium Cerebelli.
- Autonomic innervation to the vessels of the dura comes from the superior cervical sympathetic ganglia.
- Subdural space contains veins (according to the lecture).

Spaces and their contents:

- Epidural – External to the dura. meningeal arteries.
- Subdural – basically nothing. It is a potential space.
- Subarachnoid – CSF and vessels of the brain.

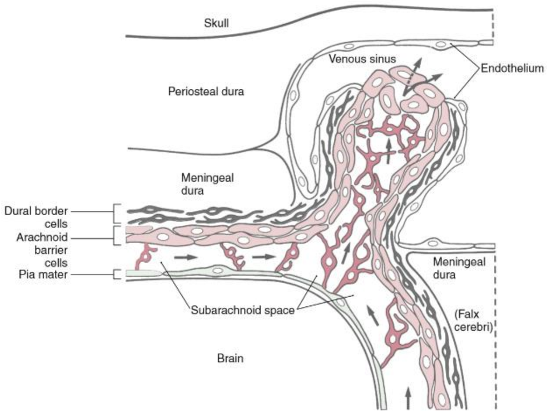
From the lecture


Epidural space
Meningeal arteries
Bone
Sinus
Dura mater
Subdural space
Arachnoid
Subarachnoidale space
CSF /Liquor/
Pia mater
Artery
Emissary vein
arachnoid trabeculae
blood vessel

**Veins in the brain drain into sinuses

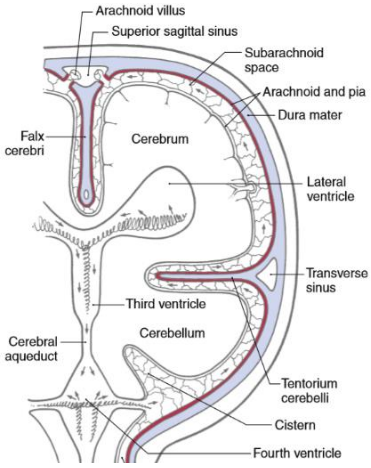
Arachnoid mater – middle layer.

- Forms the Leptomeninges, together with the Pia.
- Attached to the dura.
- The Arachnoid layer is very tight and strong – serves as a barrier for fluids.
- Subarachnoid space – between the arachnoid and pia. Contains the CSF, vessels and Cranial nerves roots. Most vessels are covered by the arachnoid and pia.
    - Brain floats in this space – protected by the CSF, that decreases its relative weight (40 grams instead of 1500 grams).
    - Some regions of the subarachnoid space are bigger. They are called Subarachnoid Cisterns.
    - The CSF, produced by the choroid plexus, enters this spaces through the foramen of Luschka and Magendie. Then it returns to the circulation through the arachnoid villi.
- Arachnoid villi – also called arachnoid granulation. protrusions of the arachnoid into the superior sagittal sinus, covered by Dural cells and endothelium of the sinus. They drain the CSF into the sinus – back to the blood.
- The subarachnoid space continues around the cranial nerves until it reaches their ganglia. Around the trigeminal ganglion it forms the trigeminal cave (Meckel's cave).


Skull
Venous sinus
Endothelium
Periosteal dura
Meningeal dura
Dural border cells
Arachnoid barrier cells
Pia mater
Subarachnoid space
Meningeal dura
(Falx cerebri)
Brain

Pia mater – inner layer.

- Forms the Leptomeninges, together with the arachnoid.
- Attached to the surface of CNS, and fused with the epineurium of cranial nerves.
- Covers most of the vessels in the subarachnoid space, sometimes with the arachnoid layer.
- Covers the blood vessels entering into the CNS.
- It is part of the Tela Choroidea, with the ependymal cell layer.


Arachnoid villus
Superior sagittal sinus
Subarachnoid space
Arachnoid and pia
Dura mater
Falx cerebri
Cerebrum
Lateral ventricle
Transverse sinus
Third ventricle
Cerebellum
Cerebral aqueduct
Tentorium cerebelli
Cistern
Fourth ventricle

Characteristics types of bleeding:

- May occur due to trauma, infections and diseases.
- Meningeal haemorrhages – Hain's 103 and 109.
    1. Extradural Haemorrhage – Found between the bone and the periosteal dura. usually caused by head injury, and bleeding of the Middle and Accessory Meningeal arteries.
    2. Subdural Haemorrhage – between the arachnoid and dura. These 2 layers strongly adhere, so there is usually no space between them. Injury can create a space between them, and blood from damaged vessels fills the new space. Usually due to tearing of Superior Cerebral veins.
    3. Subarachnoid Haemorrhage – bleeding of a vessel in the subarachnoid space. Usually caused by trauma. The blood is accumulated in the cisterns and forms pressure.

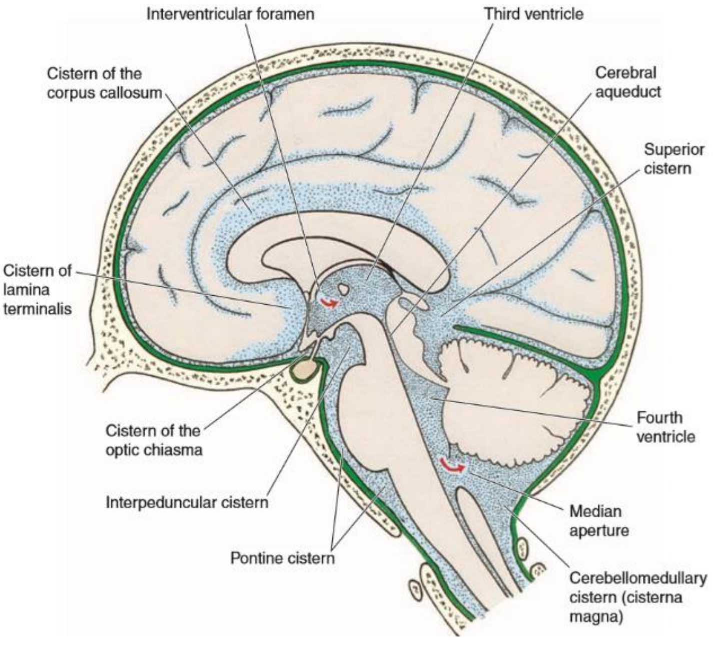
- Intra cerebral haemorrhages – rapture of one of the internal vessels.
- Other circulatory problems, not bleeding:
    1. Aneurysm – dilation of the vessels of brain, that compress areas of the brain. Most common in branches of ICA.
    2. Cerebral embolism – occlusion of a vessel by substances that flow with the blood, as clot, tumor, plaque or air. It blocks the blood flow and causes ischemia that leads to infraction (necrosis caused by problems with vascularization that lead to lack of oxygen).
    3. Arteriovenous Malformation – an area is not supplied because the communications between major arteries and veins do not develop.

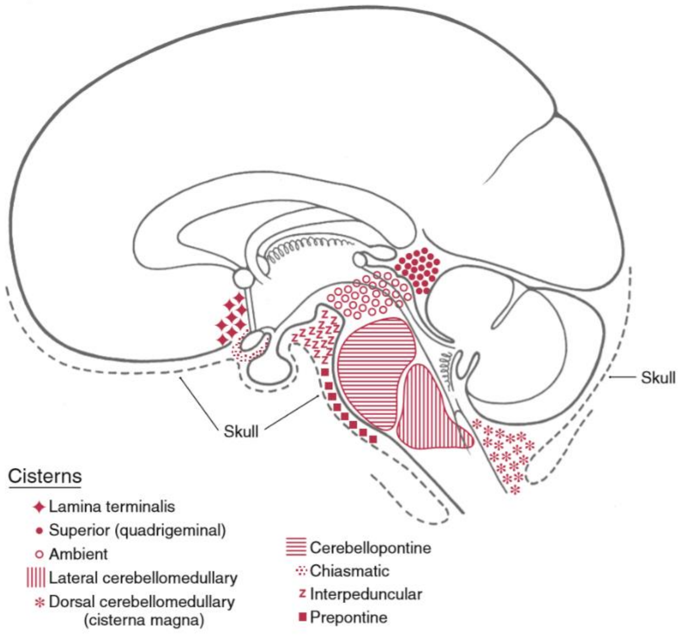
Cisterns
Hain's 105

- These are enlarged spaces of the subarachnoid space.
- Named according to the adjacent structure.
- In these spaces pass the large blood vessels. Cranial nerve roots and other structure also pass through them.

The main cisterns:

1. Cisterna Magna – Cerebellomedullary cistern. found between the cerebellum and medulla. receive CSF from 4th ventricle through foramen of Megendie.
2. Interpeduncular cistern – beneath the diencephalon, between the Crus Cerebri.
3. Cistern of optic chiasm – continues with the cistern of Lamina Terminalis, that continues into the cistern of corpus callosum.
4. Superior cistern – also called the cistern of great cerebral vein. Found behind the midbrain.
5. Ambient cistern – extensions of the superior cistern, lateral to midbrain, connecting with the interpeduncular cistern.
6. Pontine cistern – around the pons. Divided to lateral (on the sides) and median (in front).
7. Cistern of lateral cerebral fossa – area on the lateral aspect of the hemisphere.


Interventricular foramen
Third ventricle
Cistern of the corpus callosum
Cerebral aqueduct
Superior cistern
Cistern of lamina terminalis
Cistern of the optic chiasma
Fourth ventricle
Interpeduncular cistern
Median aperture
Pontine cistern
Cerebellomedullary cistern (cisterna magna)


Skull
Skull
Cisterns
✦ Lamina terminalis
● Superior (quadrigeminal)
○ Ambient
||||| Lateral cerebellomedullary
✻ Dorsal cerebellomedullary (cisterna magna)
▤ Cerebellopontine
⁘ Chiasmatic
z Interpeduncular
■ Prepontine

Topic 22 – Meninges of the Spinal Cord. Spaces and structures between meninges.

Hain's 97. Barr's 388. The Meninges generally explained in topic 3.

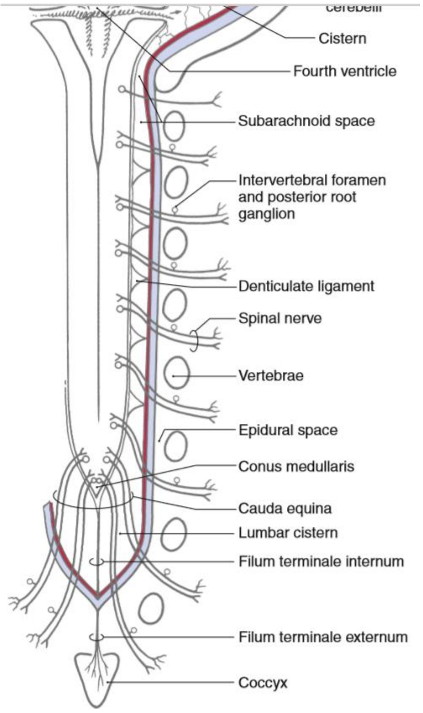
- The meninges of the spinal cord are continuous with that of the brain, but it has some differences:

Dura Mater: outer layer

- Only 1 layer – the meningeal dura, that continue from the foramen magnum. The periosteal layer of the dura in the brain ends in the foramen magnum, and does not continue to the cord. For that reason, the Dura of cord does not adhere to the vertebra.
- Forms the Dural sac – membranous sheath that makes tube around the spinal cord and cauda equine.
- The dura end as the Filum Terminale Externum, also called the Coccygeal Ligament.
- The **Epidural space** is formed around the spinal dura, and contains venous plexuses (not sinuses), lymph and fat.
  In the Epidural space local anaesthetic can be injected. The needle should pass through few layers: 1. Skin + subcutaneous tissue. 2. Supraspinous ligament. 3. Ligamentum flava. 4. Periosteum of vertebra. To enter the Subarachnoid space, for CSF sample, you should also pass through: 5. Dura mater. 6. Arachnoid mater.
- **Subdural space**, between the dura and arachnoid, is a thin potential space.
- Blood supply – by branches of major arteries close to the vertebral column.
  Each of them supply different level – vertebral, intercostal, and abdominal aorta.
- Innervation – Recurrent branches of spinal nerve.

Arachnoid mater: middle layer

- Forms the Leptomeninges, together with the Pia.
- Attached to the dura. Ends inferiorly in the Filum Terminale.
- Helps in the anchoring of spinal cord.
- The Arachnoid layer is very tight and strong – serves as a barrier of fluids.
- **Subarachnoid space** – between the arachnoid and pia. Contains the CSF, vessels and Spinal nerves roots. Most vessels are covered by the arachnoid and pia.
    - The CSF, produced by the choroid plexus, enters this space through the foramen of Luschka and Magendie. From there it ciruclates downward, around the spine, through the Lumbar Cistern, and returns to the circulation through the arachnoid villi in the brain.


Cistern
Fourth ventricle
Subarachnoid space
Intervertebral foramen and posterior root ganglion
Denticulate ligament
Spinal nerve
Vertebrae
Epidural space
Conus medullaris
Cauda equina
Lumbar cistern
Filum terminale internum
Filum terminale externum
Coccyx

Pia mater: inner layer

- Forms the Leptomeninges, together with the Arachnoid.
- Attached to the surface of CNS.
- Covers most of the vessels in the subarachnoid space, sometimes with the arachnoid layer.
- Covers the blood vessels entering into the CNS.
- Helps in the anchoring of the spinal cord by 2 structures:
  1. Denticulate ligament – 20-22 small strings that form a ligament between the lateral parts of spinal cord and the Dural sac. There is a ligament at each level of the cord, one on each side.
  2. Filum Terminale Internum – also called the Pial part of the Filum Terminale.
     Extends from the Conus Medullaris to the end of the Dural sac. Fuses with the Filum Terminale Externum at the coccyx.

Structures between the meninges:

1. Spinal nerves – set of 31 nerves that originate from the spinal cord and extend to the peripheral structure. These nerves pierce the dura mater and exit through the intervertebral foramina.
2. Blood vessels – pass in the subarachnoid space and supply the cord.
   - The Anterior and Posterior Spinal arteries originate from the superior part of the spinal cord, and descend inside the subarachnoid space.
   - The Segmental arteries originate from different arteries in different levels, and pierce the dura as they pass in the intervertebral foramina.

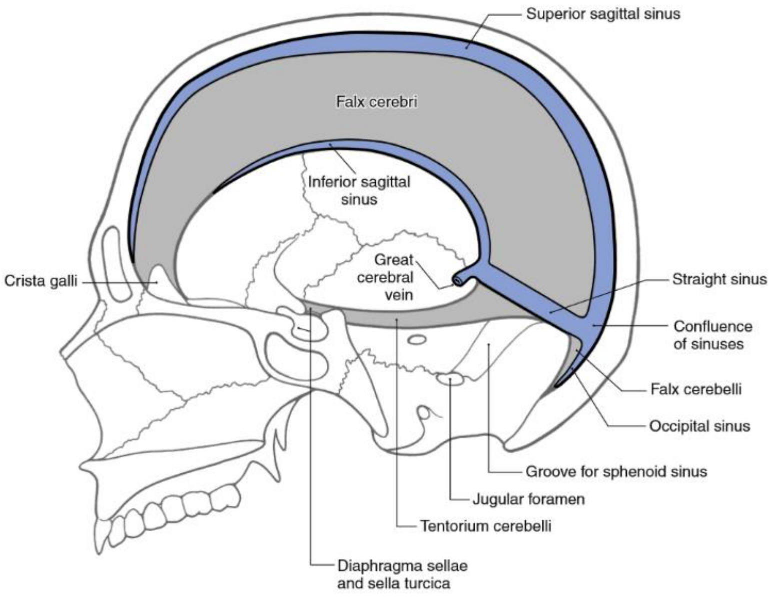
Topic 23 – Dural venous sinuses. Venous drainage of the brain

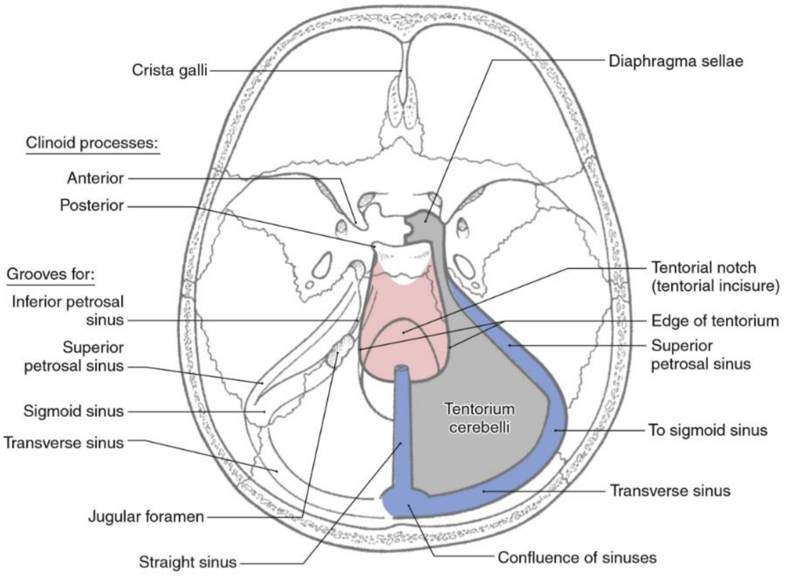
Hain's 118

- There are 2 sets of veins that drain the brain:
  1. Venous sinuses – channels covered with endothelium, formed between the 2 layers of dura mater.
  2. Veins of the brain – normal veins that drain the brain structures.
- All venous drainage of the brain exit through the internal jugular vein (IJV).
  the IJV Extends from the jugular foramen, as the continuation of the sigmoid sinus, and ends in the brachiocephalic vein.
  - Blood is collected to the venous sinuses by superficial veins. From them blood drain to the IJV through the Transverse sinus, that continue to the Sigmoid sinus, that end in the IJV.
  - From the Superior sagittal and transverse sinuses, blood also drain to the superior and inferior anastomotic veins > superficial middle cerebral vein > cavernous sinus > IJV.
- The cavernous sinus is a special sinus that collect blood and send it to the IJV, Discussed in Topic 11.
- All the veins have no valves.

Venus sinuses:

1. Superior Sagittal sinus – where the Falx Cerebri bind the skull. Separates the 2 hemispheres.
2. Inferior Sagittal sinus – at the free edge of Falx Cerebri.
3. Strait sinus – continuation of the inferior sagittal sinus, where the Falx Cerebri and Tentorium Cerebelli connect. Great cerebral vein drains into it. Drain into the transverse sinuses.
4. Transverse sinus – left and right. formed at the connection to the occipital and parietal bones.
5. occipital sinus – formed posterior to the Falx Cerebri.
6. Confluence of sinuses – receive blood from superior sagittal, occipital and strait sinus. From it the blood drains to the transverse sinus.
7. Sigmoid sinus – continuation of the transverse sinus. Continue through the sigmoid groove on the skull to the jugular foramen, where it drains to the IJV.
8. Superior and Inferior Petrosal sinuses – from the cavernous sinus to the transverse sinus (superior) and IJV (inferior).


Superior sagittal sinus
Falx cerebri
Inferior sagittal sinus
Crista galli
Great cerebral vein
Straight sinus
Confluence of sinuses
Falx cerebelli
Occipital sinus
Groove for sphenoid sinus
Jugular foramen
Tentorium cerebelli
Diaphragma sellae and sella turcica


Crista galli
Diaphragma sellae
Clinoid processes:
Anterior
Posterior
Grooves for:
Inferior petrosal sinus
Superior petrosal sinus
Sigmoid sinus
Transverse sinus
Jugular foramen
Straight sinus
Tentorial notch (tentorial incisure)
Edge of tentorium
Superior petrosal sinus
Tentorium cerebelli
To sigmoid sinus
Transverse sinus
Confluence of sinuses

Cerebral veins: blood passes in few pathways. "lateral and medial surfaces" is not an official classification, it is mentioned here to make it easier to understand.

- Lateral surface of Cerebral hemispheres drain into the superior sagittal and transverse sinuses.
  1. From the Superior Sagittal Sinus > Superior Anastomotic vein.
  2. From the transverse sinus > Inferior Anastomotic vein.
  3. Anastomotic veins drain into Superficial Middle Cerebral vein > Cavernous Sinus > IJV.

- Medial surface of Cerebral hemispheres drains into the Superior and Inferior Sagittal sinuses.
  1. Sagittal sinuses, basal vein and internal cerebral veins (from inside the brain) > strait sinus.
  2. Confluence of sinuses is the mitting of superior sagittal and strait sinus. From here blood drain into the transverse sinus > sigmoid sinus > IJV.

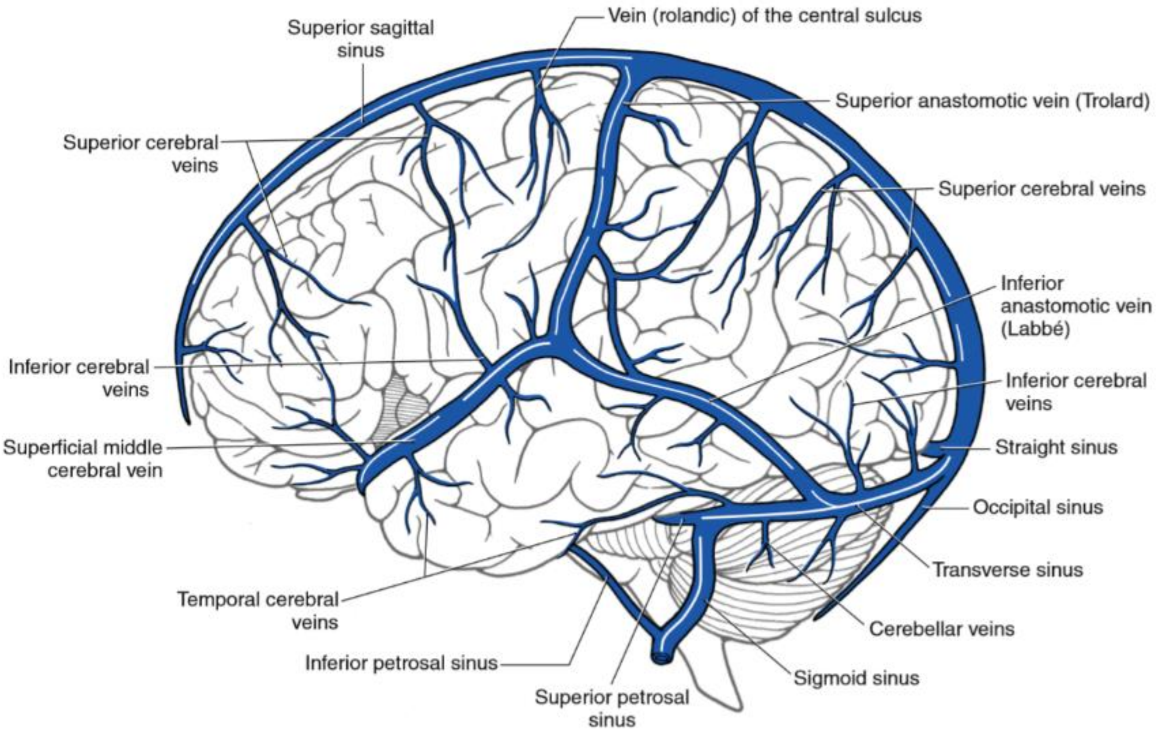
- Drainage of inner structures of hemispheres:
  1. Internal cerebral veins – 2 veins, one medial to each thalamus, next to the Tela Choroidea of 3rd ventricle. Its tributaries are Choroidal vein (follows the choroid plexus of the lateral ventricle and enter the 3rd ventricle through the interventricular foramen) + superior Thalamostriate (terminal) vein. Thalamostriate vein – close to Stria Terminalis, drains the caudate nucleus and adjacent structures.
  2. Basal vein – on the inferior surface. made by Anterior Cerebral vein from anterior part of cortex + Deep Middle Cerebral vein that drain the temporal lobe.
  3. Basal vein + internal cerebral veins > Great cerebral vein of Galen > strait sinus.
  4. The Cavernous Sinus drains into the Superior and Inferior Petrosal sinuses and the basilar plexus. Superior Petrosal drains into the transverse sinus > Sigmoid Sinus > IJV.
     Inferior Petrosal drains directly to the IJV.

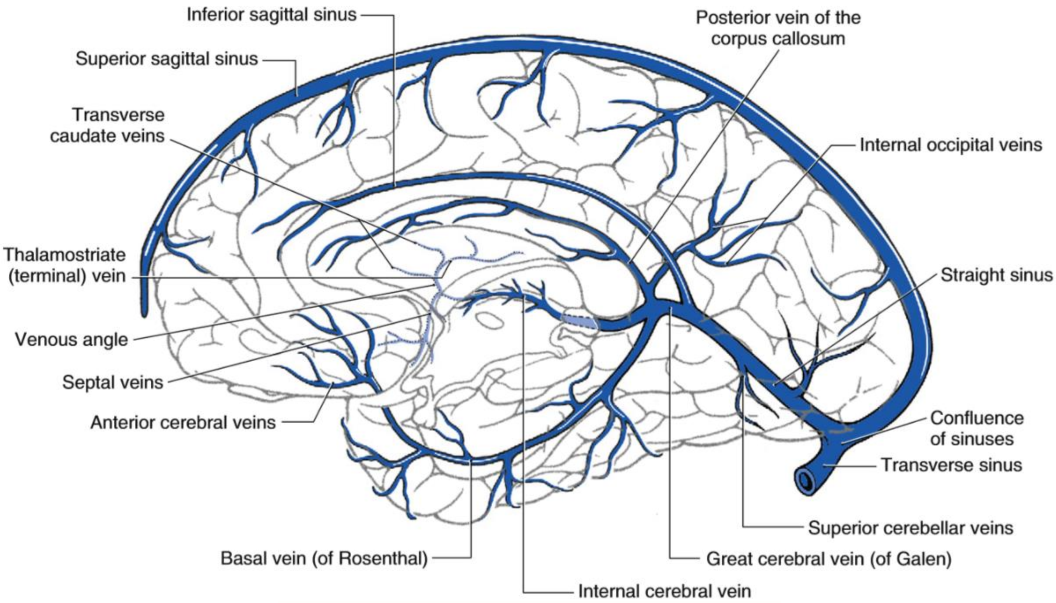
- Emissary veins – connect the Dural sinuses with veins outside of cranial cavity. Examples:
  - Parietal Emissary vein – between the Superior Sagittal Sinus and Occipital veins.
  - Mastoid Emissary vein – between the Sigmoid Sinus and Occipital and Posterior Auricular veins.
- Diploic veins – in the bones of the skull. Drain into the sinuses.

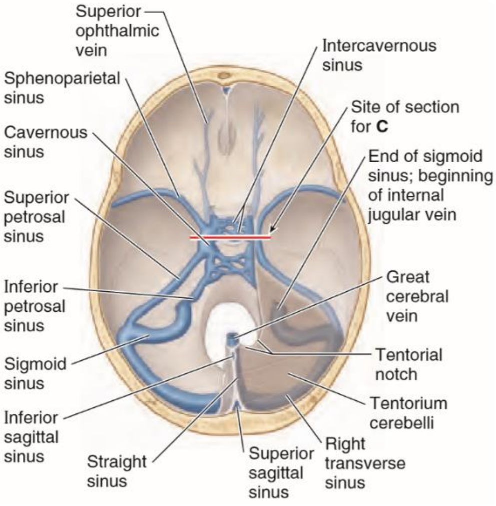
- Brainstem: drained by a venous network on its surface.
  1. Midbrain – drain to Great Cerebral vein and Basal vein.
  2. Pons and medulla – enter the Petrosal sinuses and Cerebellar veins.

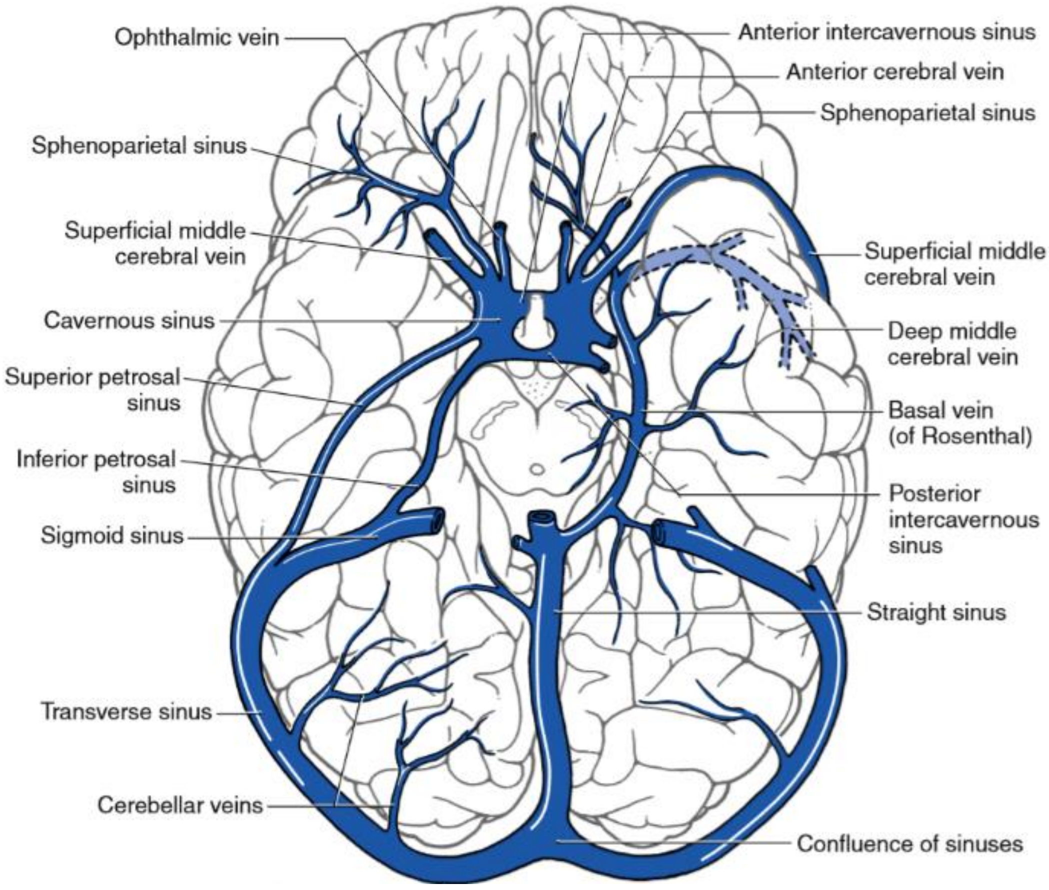
- Cerebellum: 2 veins, drain to the Strait and Transverse sinuses.
  1. Superior Cerebellar veins – from the superior surface, drain into Superior Petrosal Sinus.
  2. Inferior Cerebellar veins – from the inferior surface, drain into Inferior Petrosal Sinus.

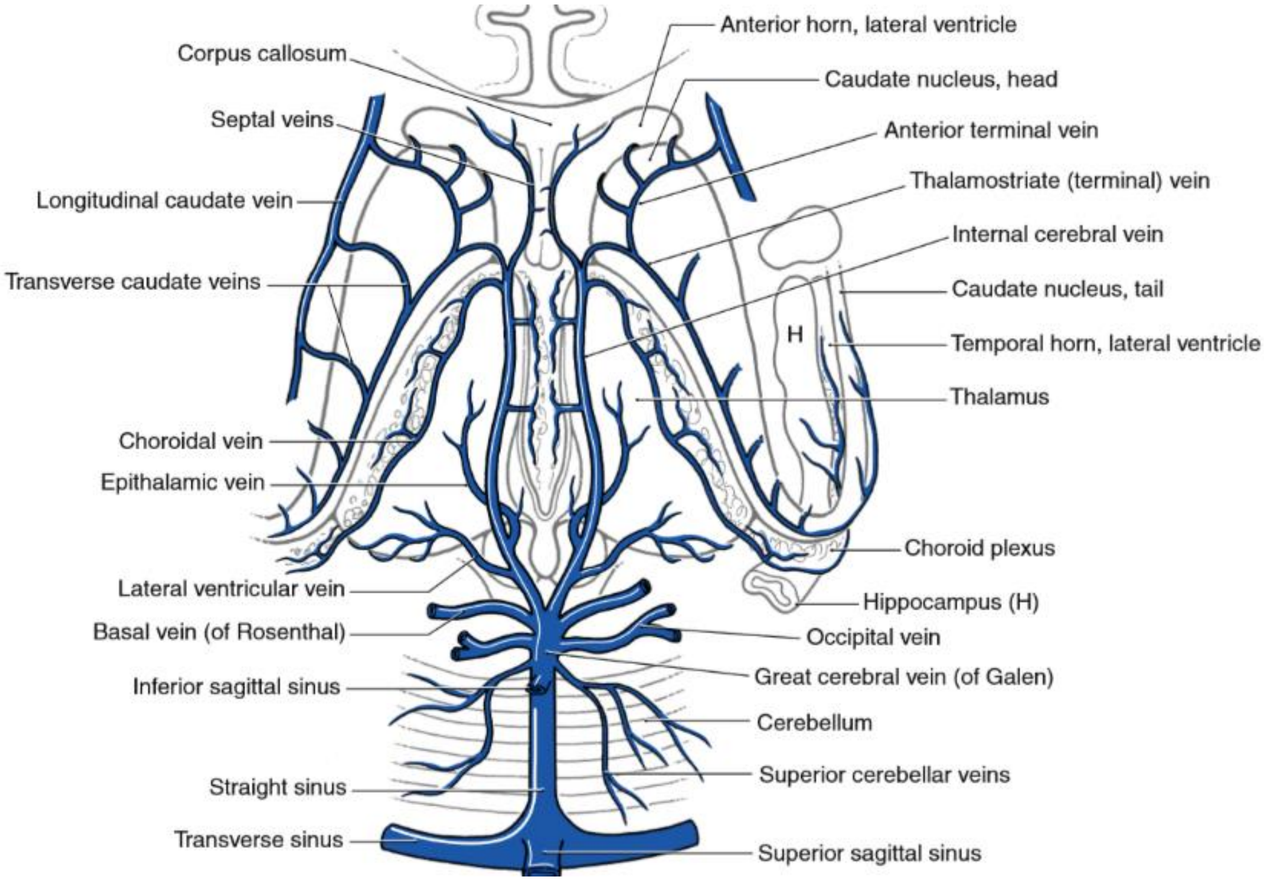
- Additional veins:
  - Bridging veins – also called Superior Cerebral veins. many small veins that drain from the hemisphere into Superior Sagittal Sinuses. They penetrate through the arachnoid and dura layers of the sinus.
  - Septal vein – next to Septum Pellucidum (on half head specimen).


Superior sagittal sinus
Vein (rolandic) of the central sulcus
Superior anastomotic vein (Trolard)
Superior cerebral veins
Superior cerebral veins
Inferior anastomotic vein (Labbé)
Inferior cerebral veins
Inferior cerebral veins
Straight sinus
Superficial middle cerebral vein
Occipital sinus
Transverse sinus
Temporal cerebral veins
Cerebellar veins
Inferior petrosal sinus
Sigmoid sinus
Superior petrosal sinus


Inferior sagittal sinus
Posterior vein of the corpus callosum
Superior sagittal sinus
Transverse caudate veins
Internal occipital veins
Thalamostriate (terminal) vein
Straight sinus
Venous angle
Septal veins
Anterior cerebral veins
Confluence of sinuses
Transverse sinus
Superior cerebellar veins
Basal vein (of Rosenthal)
Great cerebral vein (of Galen)
Internal cerebral vein


Superior ophthalmic vein
Intercavernous sinus
Sphenoparietal sinus
Site of section for C
Cavernous sinus
End of sigmoid sinus; beginning of internal jugular vein
Superior petrosal sinus
Great cerebral vein
Inferior petrosal sinus
Tentorial notch
Sigmoid sinus
Tentorium cerebelli
Inferior sagittal sinus
Right transverse sinus
Straight sinus
Superior sagittal sinus


Ophthalmic vein
Anterior intercavernous sinus
Anterior cerebral vein
Sphenoparietal sinus
Sphenoparietal sinus
Superficial middle cerebral vein
Superficial middle cerebral vein
Cavernous sinus
Deep middle cerebral vein
Superior petrosal sinus
Basal vein (of Rosenthal)
Inferior petrosal sinus
Posterior intercavernous sinus
Sigmoid sinus
Straight sinus
Transverse sinus
Cerebellar veins
Confluence of sinuses


Anterior horn, lateral ventricle
Corpus callosum
Caudate nucleus, head
Septal veins
Anterior terminal vein
Thalamostriate (terminal) vein
Longitudinal caudate vein
Internal cerebral vein
Transverse caudate veins
Caudate nucleus, tail
H
Temporal horn, lateral ventricle
Thalamus
Choroidal vein
Epithalamic vein
Choroid plexus
Lateral ventricular vein
Hippocampus (H)
Basal vein (of Rosenthal)
Occipital vein
Great cerebral vein (of Galen)
Inferior sagittal sinus
Cerebellum
Superior cerebellar veins
Straight sinus
Transverse sinus
Superior sagittal sinus

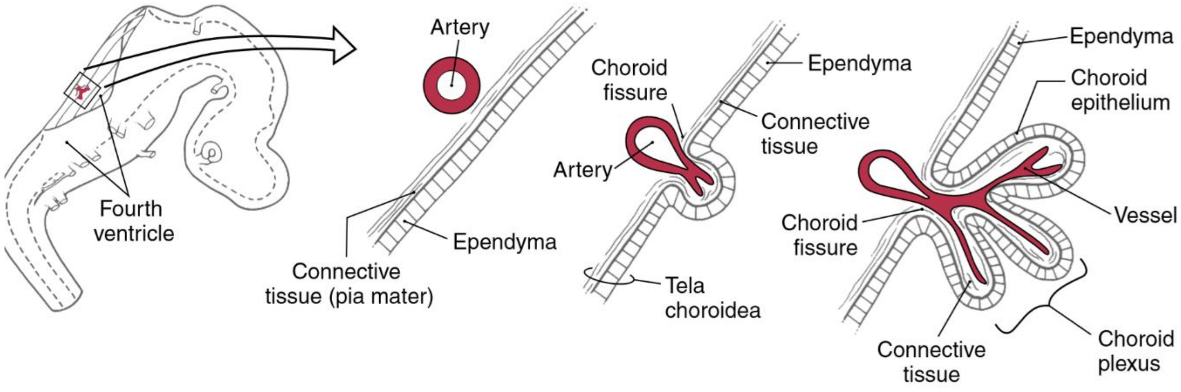
Topic 24 – Demonstration of the structures producing Cerebrospinal Fluid. Circulation of the CSF

Hain's 87. Barr's 394.

- The CSF is filtered from blood by the Choroid Plexus. It fills the cavities (ventricles) of different parts of the brain and the subarachnoid space. It circulates between them until it is reabsorbed to blood.
- Functions:
    1. Surround the CNS and make it float inside the dura, to protect from damage.
    2. Mechanical support.
    3. Enable control of intracranial pressure by changing the amount of CSF.
    4. Distribute substances and Clear waste products.
- Composition: it is colourless and has very little proteins and immune cells.
  Normal volume – 120-140 mL.
  Compared to plasma, it has more Cl, Na and Mg, less K, Ca glucose and proteins.

The structure of choroid plexus:

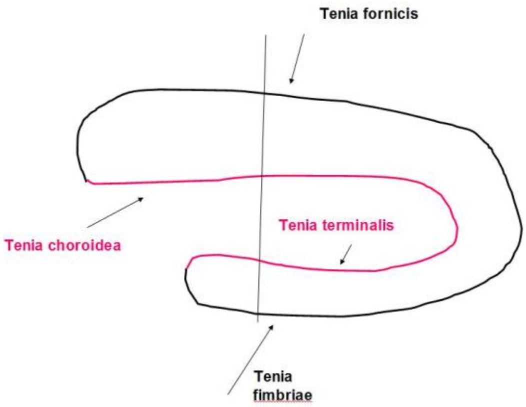
- Made of 3 layers: ependymal cell layer (lamina epithelialis), pia mater and blood vessels.
    1. Ependymal cell layer: covers the ventricles of the brain and the central canal.
    2. Pia mater: the inner meningeal layer, that covers the surfaces of the brain.
       ** Tela Choroidea = ependymal cell layer + pia mater.
    3. Arteries: they penetrate from the inside of brain into the space of the ventricle, and pull the Tela Choroidea together with them.
       Arteries supplying the choroid plexus:
        - lateral ventricles – branches of Lateral Posterior Choroidal artery (branch of P2) and Anterior Choroidal artery (to inferior horn, branch of ICA).
        - 3rd ventricle – branches of Medial Posterior Choroidal artery (branch of P2).
        - 4th ventricle – branches of Posterior Inferior Cerebellar artery.
        - The part that extend from foramen of Luschka – Anterior Inferior Cerebellar artery.

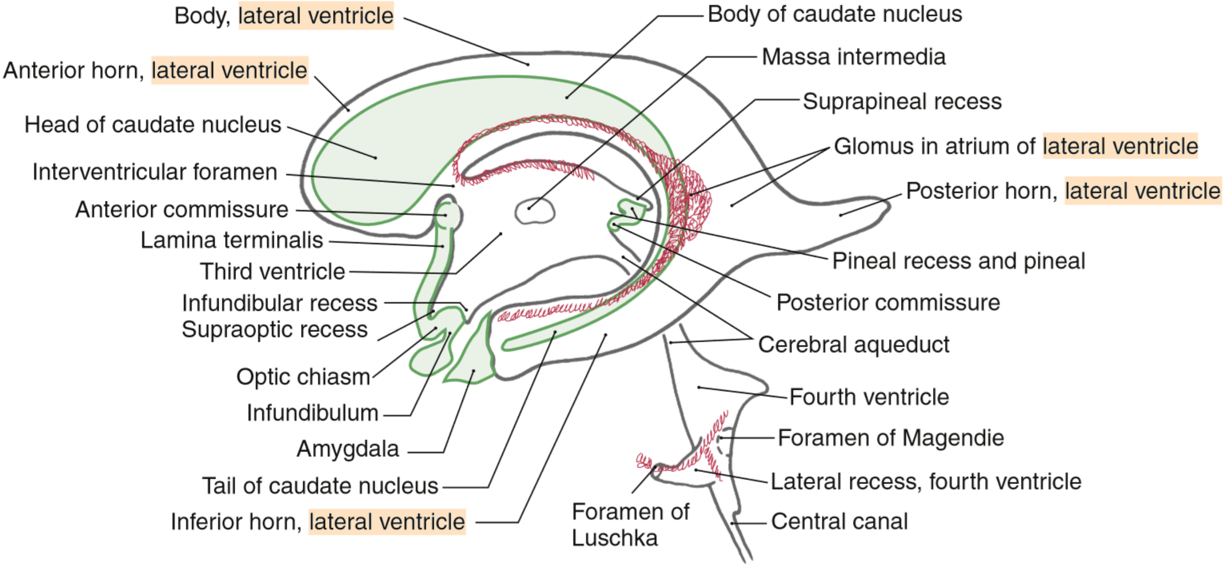

Fourth ventricle
Artery
Connective tissue (pia mater)
Ependyma
Choroid fissure
Artery
Ependyma
Connective tissue
Tela choroidea
Ependyma
Choroid epithelium
Vessel
Choroid fissure
Connective tissue
Choroid plexus

- The Choroid Plexus makes folds – villi.
- The endothelial cells are fenestrated, to allow exchange of molecule from blood.

Locations of the choroid plexus:

- Lateral ventricle: the choroid plexus is connected to the walls of lateral ventricle by Tenia. Each Tenia is named after the structure it is attached to:
  1. Tenia Choroidea – covers the floor of the central part of the ventricle. It is medial to Lamina Affixa Thalami (epithelium that covers the superior part of Thalamus).
  The Tenia Choroidea continues to the inferior horn as the Tenia Terminalis, that attaches Stria Terminalis.
  2. Tenia Fornicis – on the medial side of the central part of the ventricle, adjacent to fornix. It continues to the inferior horn as Tenia Fimbriae, that attaches to the fimbria of Hippocampus.
  3. The glomus – clump of choroid plexus that is found in the atrium.


Tenia fornicis
Tenia choroidea
Tenia terminalis
Tenia fimbriae


Body, lateral ventricle
Anterior horn, lateral ventricle
Head of caudate nucleus
Interventricular foramen
Anterior commissure
Lamina terminalis
Third ventricle
Infundibular recess
Supraoptic recess
Optic chiasm
Infundibulum
Amygdala
Tail of caudate nucleus
Inferior horn, lateral ventricle
Body of caudate nucleus
Massa intermedia
Suprapineal recess
Glomus in atrium of lateral ventricle
Posterior horn, lateral ventricle
Pineal recess and pineal
Posterior commissure
Cerebral aqueduct
Fourth ventricle
Foramen of Magendie
Lateral recess, fourth ventricle
Central canal
Foramen of Luschka

- 3rd ventricle – The choroid plexus continues from the lateral ventricle into the 3rd ventricle through the interventricular foramina. it is suspended from the roof of the 3rd ventricle, by a connection called Tenia Thalami, because it is connected to the Stria Medullairs Thalami.
- 4th ventricle – the choroid plexus is not continuous with that of the other ventricles.
  It is suspended from the inferior part of the roof of the 4th ventricle.
  It also extends through the foramina of Luschka to the subarachnoid space. This extension is called "Bochdale bunch of flowers".

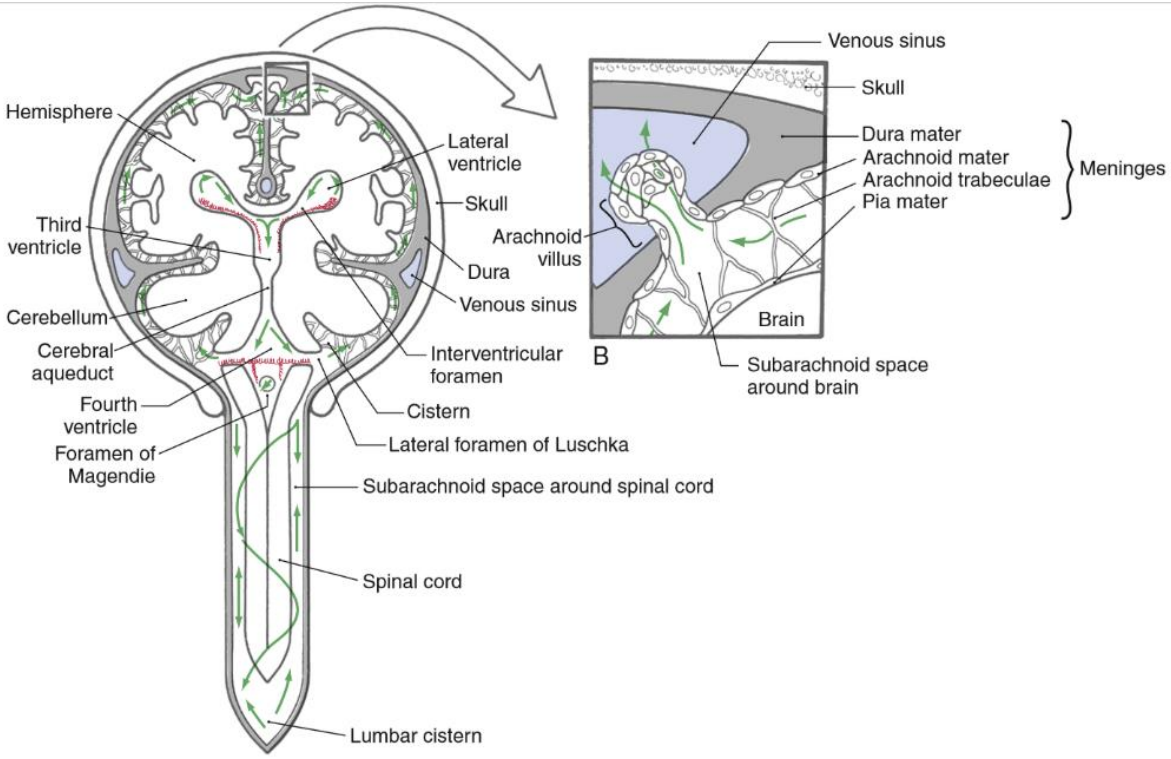
Circulation of CSF:

- The CSF is constantly produced and reabsorbed. These actions make pressure gradient that is the driving force for its circulation. In addition, the Ependymal cells have cilia that push the CSF.
- It begins in the ventricles, passing between them. At the 4th ventricle it continues to the subarachnoid space through the foramina of Luschka and Magendie.

- Pathway – lateral ventricle > interventricular foramen > 3rd ventricle > cerebral aqueduct > 4th ventricle > foramen of Luschka and Magendie > subarachnoid spaces (cisterns) around the brain and spinal cord (cisterna magna + space around the spinal cord > pontine cistern > basal cisterns > medial and lateral surfaces of hemispheres > reabsorption through the arachnoid villi > superior sagittal sinus (enter into blood).
- Important subarachnoid spaces in the course –
  1. Cerebellomedullary cistern – also called cisterna magna. It is posterior to 4th ventricle and anterior to the cerebellum.
  2. Lumbar cistern – at the end of Dural sac, surrounds the cauda equine and lower spinal cord. The CSF descend posteriorly and ascend anteriorly.
  3. Pontine cistern – on the sides of the pons.
  4. Basal cisterns – cisterns beneath the brain stem and diencephalon, including interpeduncular, pontine and cistern of optic chiasm.

Reabsorption of CSF:

- After passing through the subarachnoid spaces, CSF reaches to the arachnoid villi, also called arachnoid granulation, that extend into the superior sagittal sinus. They are seen on the top of the Dura mater, and make depressions on the skull.
- These villi enable passage only in one direction – from the subarachnoid space to the sinus. This makes the blood-CSF barriers, so CSF enters into the blood stream, but blood doesn't go the opposite way.
- The movement of CSF depends on the pressure differences. If the pressure of CSF is higher than that of the venous sinus – CSF will flow into the sinus. If CSF pressure is lower – it would not flow.
- About 350 mL of CSF are reabsorbed to blood every day.


Hemisphere
Lateral ventricle
Skull
Third ventricle
Dura
Venous sinus
Cerebellum
Cerebral aqueduct
Interventricular foramen
Fourth ventricle
Cistern
Foramen of Magendie
Lateral foramen of Luschka
Subarachnoid space around spinal cord
Spinal cord
Lumbar cistern
Venous sinus
Skull
Dura mater
Arachnoid mater
Arachnoid trabeculae
Pia mater
Meninges
Arachnoid villus
Brain
B
Subarachnoid space around brain

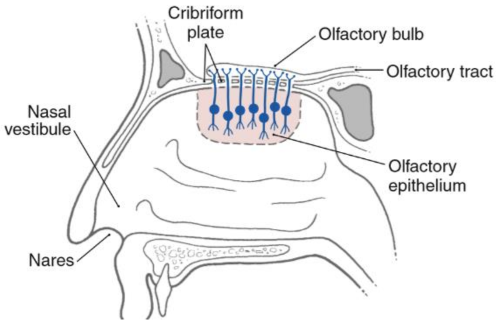
Topic 25 – Demonstration of the Olfactory Pathway (also on coronal sections)

Hain's 313. Barr's 261.

- Olfaction is the sense of smelling. It is not dominant in humans, but it doesn't mean you shouldn't use deodorant. In other animals it is more developed.
- It is the only sense that is not processed first in the Thalamus, but go directly to cortex.
- It has special relation with the limbic system, as it affects many of its structures.
- Pathway: Olfactory receptors > Olfactory Bulb and Tract > Medial and Lateral olfactory Stria > Anterior Commissure and cortical areas as Amygdala.

1. Olfactory Receptors:

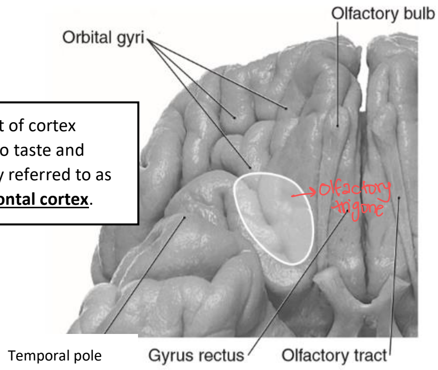
- The receptors are found in the olfactory mucosa, in the roof of the nasal cavity, inferior to the cribriform plate.
- The olfactory epithelium has olfactory cilia, in which the receptors are found. The epithelium is covered by mucous.
- Similarly to taste, the olfactory epithelium has 3 cell types – olfactory receptors, supporting (sustentacular) cells and basal cells.
- The olfactory receptor has 2 processes –
  1. Apical dendrite – extend to the mucosa surface to sense odorant (smell inducing) molecules.
  2. Unmyelinated axon – go to the brain. axons of many receptors form bundle called the Olfactory Fila. These Fila form the olfactory nerve – cranial nerve 1.
- They Olfactory Fila pass through the cribriform plate, and unite to form the Olfactory Bulb.

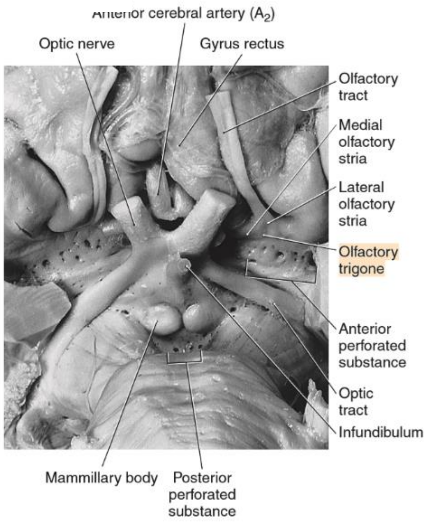

Cribriform plate
Olfactory bulb
Olfactory tract
Nasal vestibule
Olfactory epithelium
Nares

2. Olfactory Bulb and Tract:

- Found in the olfactory sulcus of the frontal cortex, next to the strait gyrus.
- The bulb lies on the cribriform plate of ethmoid bone. Beneath the frontal lobe.
- The bulb continues posteriorly as the olfactory tract (called Lateral Olfactory Tract in the book).
- The olfactory tract extends posteriorly to the anterior perforated substance. This area is called the olfactory trigone, because the fibers split into 2 – Lateral Olfactory Stria and Medial Olfactory Stria.
- From them the information continues to different regions of the cortex.
- Anterior Olfactory nucleus – formed by many scattered cell in the olfactory bulb and tract. Makes communication between the Olfactory Bulbs of both sides, through the Anterior Commissure.

Encircled area – part of cortex related specifically to taste and olfaction. commonly referred to as the **medial orbitofrontal cortex**.


Orbital gyri
Olfactory bulb
olfactory trigone
Temporal pole
Gyrus rectus
Olfactory tract

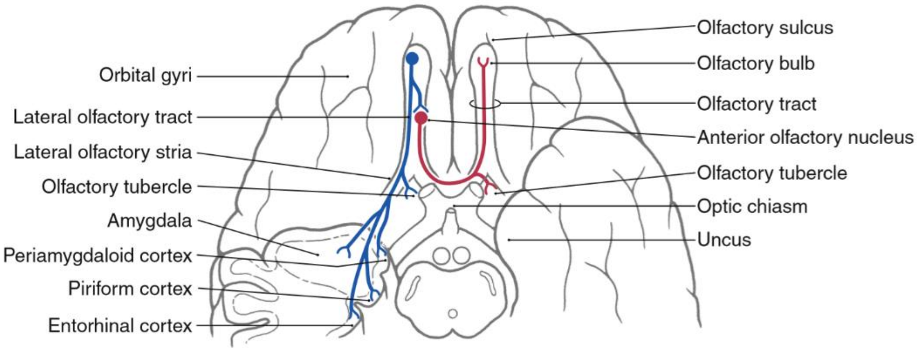

Anterior cerebral artery (A_2)
Optic nerve
Gyrus rectus
Olfactory tract
Medial olfactory stria
Lateral olfactory stria
Olfactory trigone
Anterior perforated substance
Optic tract
Infundibulum
Mammillary body
Posterior perforated substance

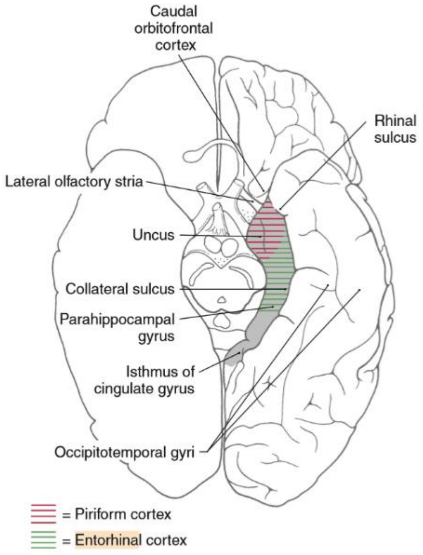
→ nerve responsible for tongue (taste)
corda tympani → doesn't go directly to CNS
vagus
glossopharyngeal

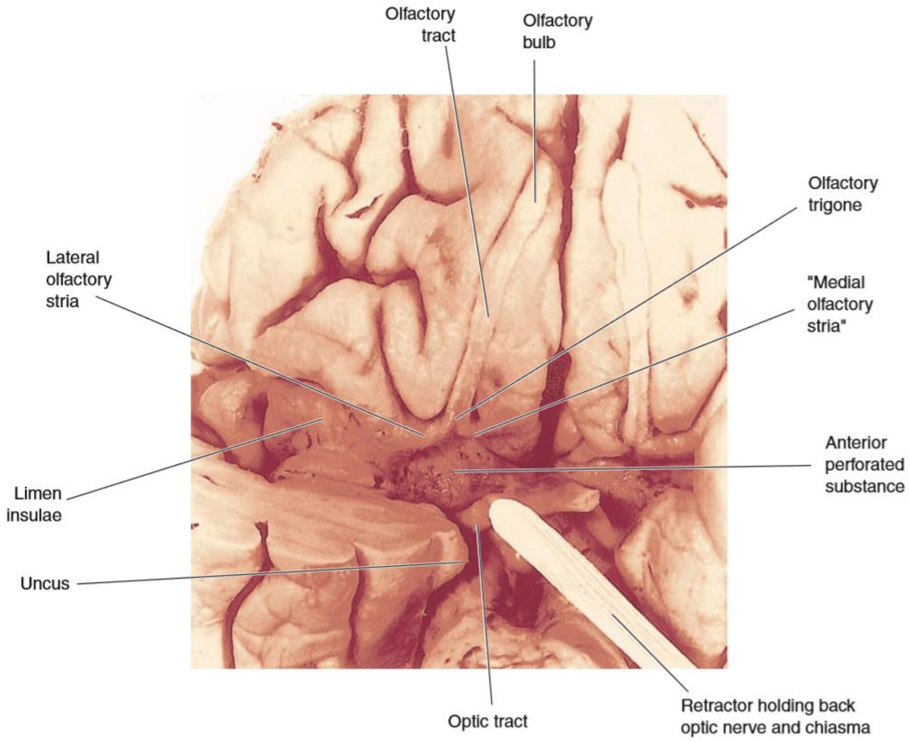
3. Cortex:

- Anterior Commissure – at the anterior part of 3rd ventricle. Enables passage of olfactory information between the 2 hemispheres.
- Amygdala – part of the limbic system. Receives olfactory information.
- Piriform cortex – on the uncus, anterior part of the parahippocampal gyrus. Makes the primary olfactory cortex.
- Entorhinal cortex – on the parahippocampal gyrus.
- Olfactory Tubercle – part of the ventral striatum of basal ganglia, together with nucleus Accumbens. It is a little bump in the anterior perforated substance, at the end of olfactory tract. barely seen.
- Periamygdaloid cortex – part of the cortex that is anterior to the amygdala.

Most of these structures send information to the Hypothalamus and Thalamus.

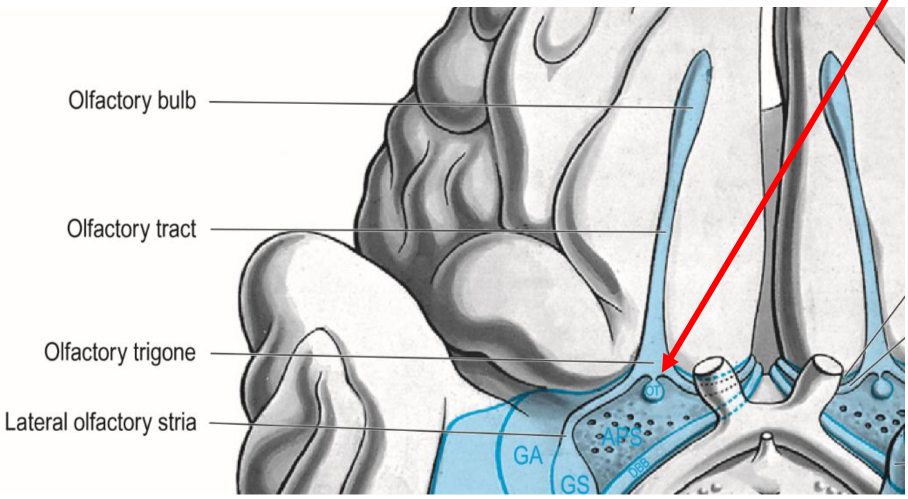

Orbital gyri
Lateral olfactory tract
Lateral olfactory stria
Olfactory tubercle
Amygdala
Periamygdaloid cortex
Piriform cortex
Entorhinal cortex
Olfactory sulcus
Olfactory bulb
Olfactory tract
Anterior olfactory nucleus
Olfactory tubercle
Optic chiasm
Uncus


Caudal orbitofrontal cortex
Rhinal sulcus
Lateral olfactory stria
Uncus
Collateral sulcus
Parahippocampal gyrus
Isthmus of cingulate gyrus
Occipitotemporal gyri
= Piriform cortex
= Entorhinal cortex


Olfactory tract
Olfactory bulb
Olfactory trigone
Lateral olfactory stria
"Medial olfactory stria"
Anterior perforated substance
Limen insulae
Uncus
Optic tract
Retractor holding back optic nerve and chiasma

The Vomeronasal system:

- According to the lecture it exists.
- According to the Barr's it Appears for short period during embryonic development. In other animals it is present and important.
- Responsible for detection of Pheromones – smell molecules of other humans, that affect person's behaviour unconsciously.
- The pheromones are sensed by the Vomeronasal organ, found at the posterior part of nasal septum.
- The information is transmitted by the 'Terminal nerve' – cranial nerve zero. It is **microscopic** nerve, so it **cannot be seen on the specimen**, but it basically should be medial to the olfactory nerve.


Olfactory bulb
Olfactory tract
Olfactory trigone
Lateral olfactory stria
OT
APS
GA
GS
DBB

OT – olfactory tubercle

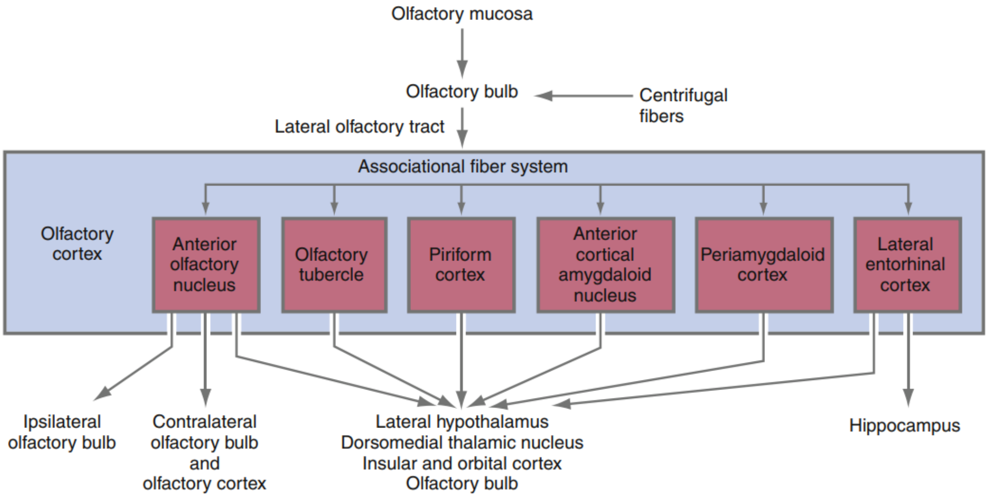

Olfactory mucosa
Olfactory bulb
Centrifugal fibers
Lateral olfactory tract
Associational fiber system
Olfactory cortex
Anterior olfactory nucleus
Olfactory tubercle
Piriform cortex
Anterior cortical amygdaloid nucleus
Periamygdaloid cortex
Lateral entorhinal cortex
Ipsilateral olfactory bulb
Contralateral olfactory bulb and olfactory cortex
Lateral hypothalamus
Dorsomedial thalamic nucleus
Insular and orbital cortex
Olfactory bulb
Hippocampus

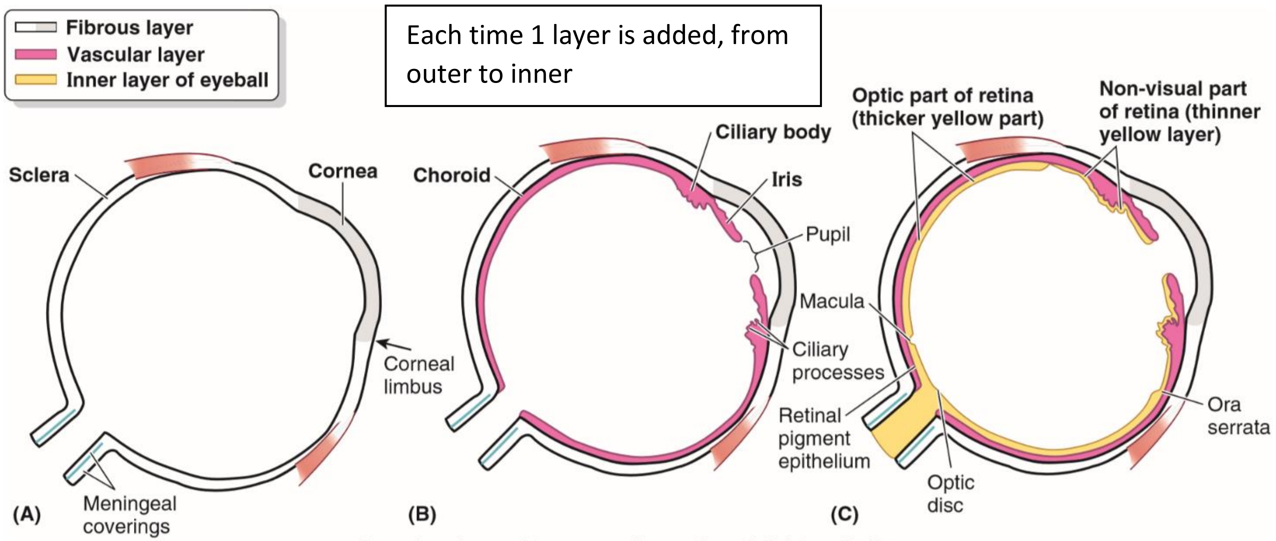
Figure 23-8. Major projections of the olfactory cortex.

* pupillary accommodation reflex

Topic 26 – Demonstration of the coats of the Eyeball on the eye specimen

Moore 893. Hain’s 267. Ross 900.

- The eyeball is located in the orbit.
- It has 3 layers – Fibrous layer, Vascular layer and Inner layer.
- Surrounding the eyeball there is an additional layer of connective tissue, to support it inside the orbit. Contains fat. Episcleral space – a potential space between the eye and the outer CT, that allows movement of the eye.


Fibrous layer
Vascular layer
Inner layer of eyeball
Sclera
Cornea
Corneal limbus
Meningeal coverings
(A)
Choroid
Ciliary body
Iris
Pupil
Macula
Ciliary processes
Retinal pigment epithelium
(B)
Optic part of retina (thicker yellow part)
Non-visual part of retina (thinner yellow layer)
Ora serrata
Optic disc
(C)

Each time 1 layer is added, from outer to inner

Superior views of transversely-sectioned right eyeball

1. Fibrous layer – outer coat:

- Also called Corneoscleral layer. Composed of sclera and cornea.
- Sclera –
  - The white layer that we see.
  - It is opaque (not transparent), and it covers 5/6 of the eyeball.
  - The extrinsic muscles of the eye attach to it.
  - It is vascular.
  - Its anterior part is covered by the Conjunctiva, which is vascular layer that continues to the internal layer of eyelid.
  - Continuous with the Dura mater.
  - Connects to the fascial sheath of the eyeball, that continues posteriorly and forms the socket for the eyeball.
  - Area Cribrosa – layer of collagen in the sclera through which the optic nerve fibers exit.

- Cornea –
  - transparent part. It is transparent due to the collagen fibers arrangement, that allow light to pass and reach the retina.
  - It is found on the front 1/6.
  - Corneal limbus – the angle formed at the Corneoscleral junction. Because it is more convex than the sclera – looks like a bump when you watch it from the side.

  - Completely avascular. Supplied by diffusion from the surrounding capillaries and from the Aqueous Humour and lacrimal fluid.
  - Free nerve endings of the ophthalmic nerve make it touch sensitive, and activate the corneal reflex, that make the eyelid close when something touches it.
  - Not covered by the conjunctiva.

2. Vascular layer – middle coat:

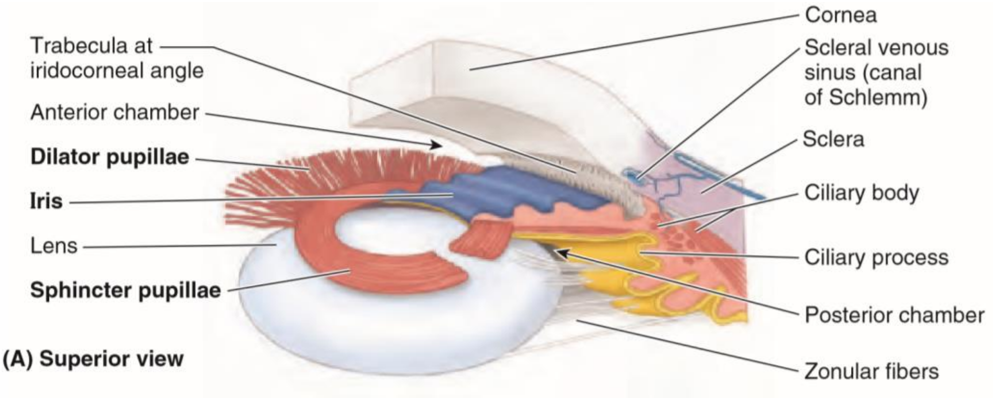
- Also called Uvea. Consist of Choroid, Ciliary Body and Iris.
- Choroid –
  - Dark layer (pigmented). Between the retina and sclera.
  - Contains many vessels. The large vessels are outer, closer to the sclera.
    The smaller vessels are inner, closer to the retina, form the capillary lamina of choroid plexus. They supply the photoreceptor cells.

- Ciliary body –
  - Ring structure that surround the iris and connect it to the choroid.
  - Part of it is the Ciliary Muscle – attaches the lens through the Zonule Fibers (also called suspensory ligament). When the Ciliary muscle contracts or relaxes, the curvature of the lens changes to accommodate the sight.
    the muscle is innervated by Edinger-Westphal nucleus.
  - Another part is the Ciliary Processes – these are folds on the ciliary body that secrete the Aqueous Humour, that fills the anterior and posterior chambers of the eye and nourishes the avascular lens and cornea.

- Iris –
  - Anterior to the lens. Pigmented – make the eye color of person.
  - It is a thin contractile diaphragm.
  - It has a black hole in its center – the pupil. Its diameter controlled by 2 muscles of the iris:
    - ✈ Sphincter Pupillae – ring of circular muscles at the edge of iris. As it contracts, under parasympathetic control, the pupil becomes smaller.
    - ✈ Dilator Pupillae – radial muscle fibers. As it contracts, under sympathetic control, pupil becomes bigger.

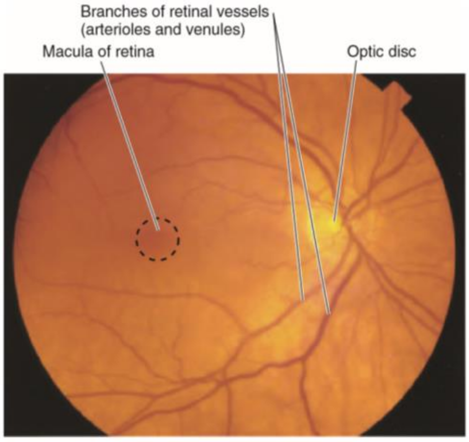
**3 intrinsic muscles of the eye:

Sphincter Pupillae, Dilator Pupillae – in the iris.
Ciliary muscle – part of ciliary body.


Trabecula at iridocorneal angle
Anterior chamber
Dilator pupillae
Iris
Lens
Sphincter pupillae
(A) Superior view
Cornea
Scleral venous sinus (canal of Schlemm)
Sclera
Ciliary body
Ciliary process
Posterior chamber
Zonular fibers

3. Retina – inner layer:

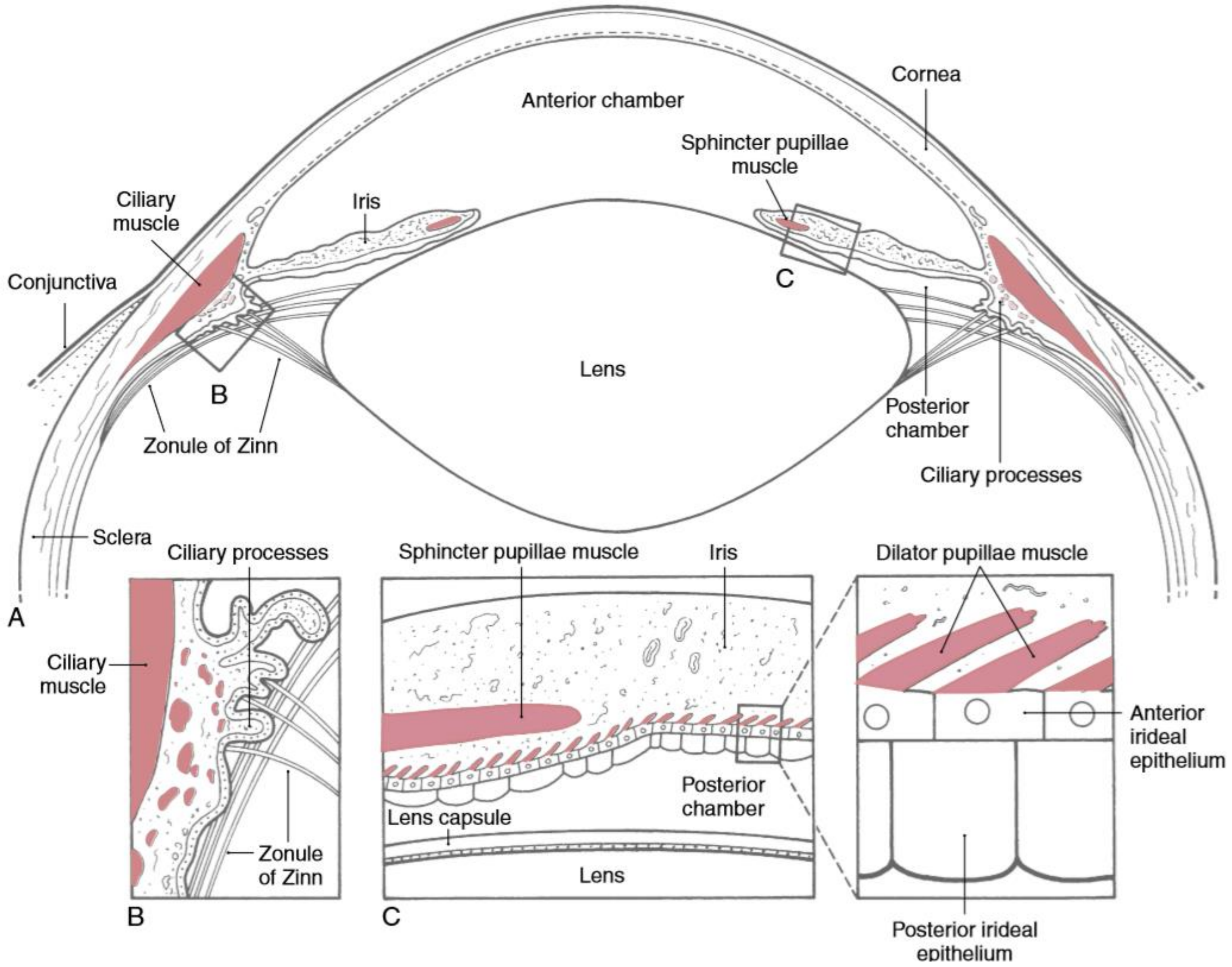
- In the specimen its look like a white sheet. can be stripped off, so you won't necessarily see it.
- Has optic part and non-visual part.
- Optic part – also called Pars Optica.
    - It is the Sensory part.
    - has Neural layer – inner. contain the photoreceptor cells and additional neural cells that sense the light. Central retinal vessels pass through it and are seen in the model.
    - and Pigmented layer – outer. single layer that absorb light, to reduce the light scattering.
    - Fundus – the area on which light is focused.
    - Optic disc – the point through which the optic nerve enters. It is a blind spot, because it has no photoreceptor cells.
    - Macula Lutea – lateral to the optic disc. The area that is specialized in acute vision. In its center the Fovea Centralis is found.
    - Fovea Centralis – at the center of the Macula Lutea. It is the area of most acute vision, and has only Cons photoreceptor. Its center is the Foveola that has no vessels.

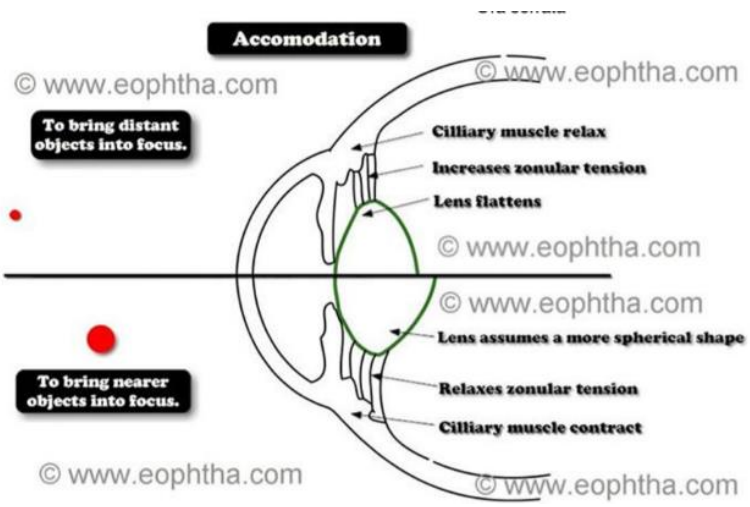


- Non-visual retina – also called Pars Ceca.
    - Found anteriorly.
    - Extends over the ciliary body and posterior part of iris.
    - Has no photoreceptor cells and all other layers of the retinal epithelium.

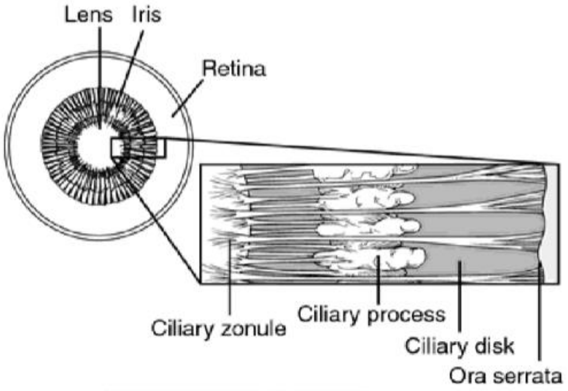
- Ora Serrata – border between the 2 parts.

- Blood supply to the retina:
    - To Photoreceptors – from the capillary plexus of the choroid layer.
    - The other layers are supplied by the central artery of retina, branch of the ophthalmic artery (which is branch of the ICA). The Central vein of Retina drains it.


Anterior chamber
Cornea
Sphincter pupillae muscle
Ciliary muscle
Iris
Conjunctiva
C
Lens
B
Posterior chamber
Zonule of Zinn
Ciliary processes
Sclera
A
Ciliary processes
Ciliary muscle
Zonule of Zinn
B
Sphincter pupillae muscle
Iris
Posterior chamber
Lens capsule
Lens
C
Dilator pupillae muscle
Anterior irideal epithelium
Posterior irideal epithelium


Accomodation
To bring distant objects into focus.
Cilliary muscle relax
Increases zonular tension
Lens flattens
Lens assumes a more spherical shape
To bring nearer objects into focus.
Relaxes zonular tension
Cilliary muscle contract

© www.eophtha.com


Lens
Iris
Retina
Ciliary zonule
Ciliary process
Ciliary disk
Ora serrata

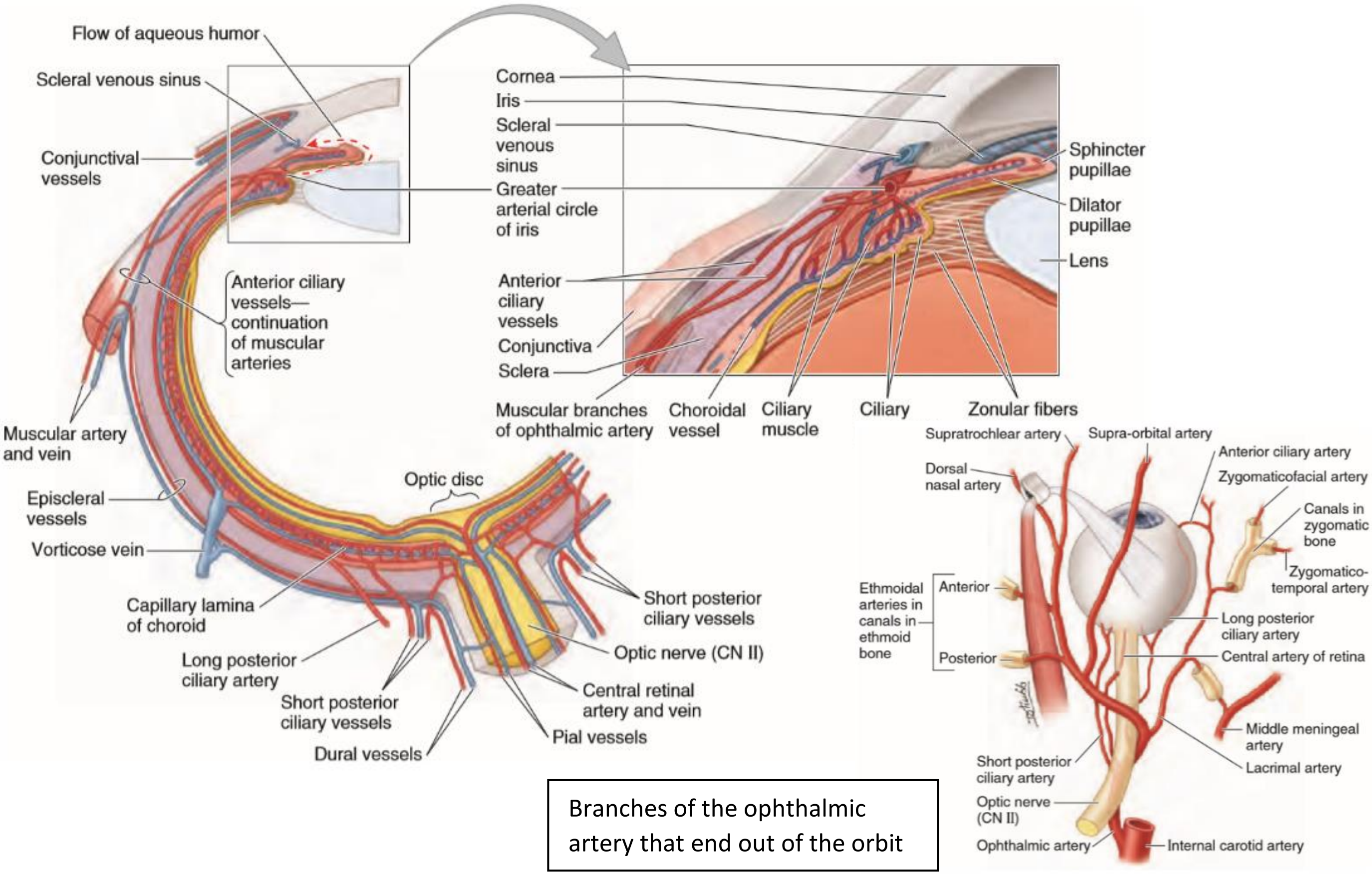
Topic 27 – Demonstration of the blood vessels of the Eye (on the eye model). Production, Circulation and Resorption of the Aqueous Humour

Ross 900. Moore 889.

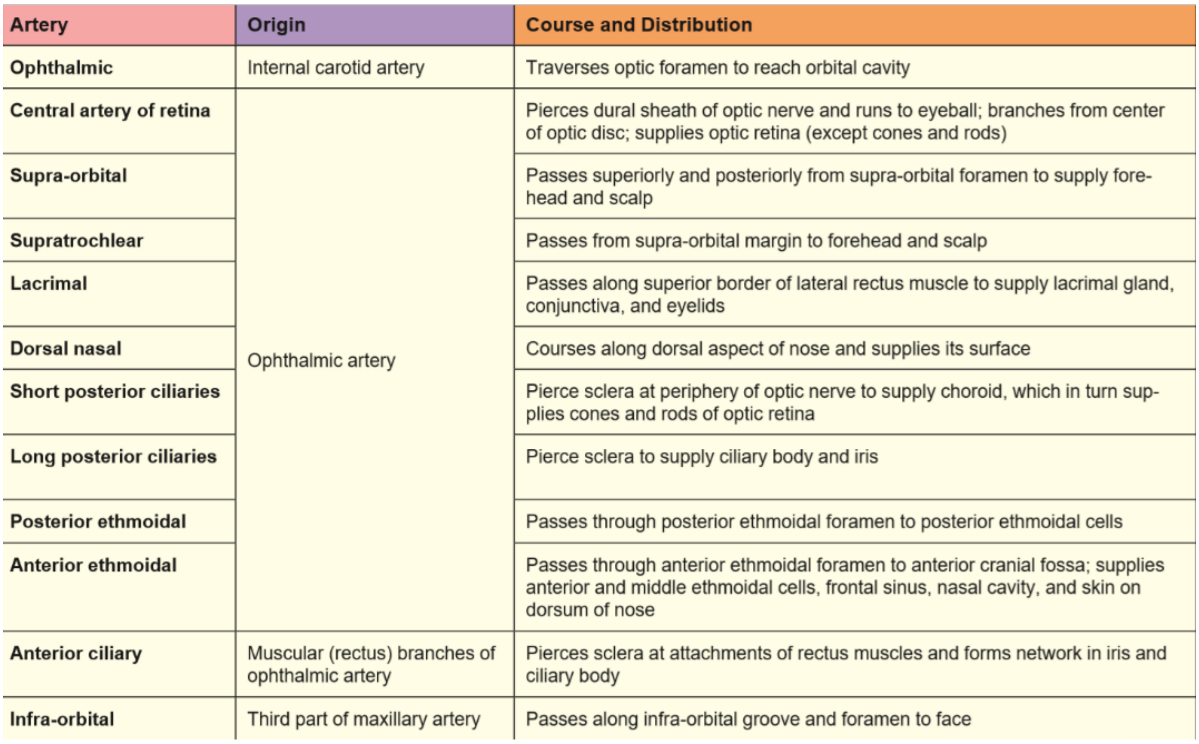
Arteries of the eye:

Different layers of the eye are supplied by different vessels –

- Generally, the eye is supplied by the Ophthalmic artery – branch of the Internal Carotid artery. It Enters the orbit through the Optic foramen and the Optic canal, and gives many branches.
- Inner layer – Central artery of the Retina – branch of the ophthalmic artery. Pierces the Dura and enters the eye with the Optic nerve, and supply the inner part of retina (except the photoreceptor cells) and the Optic nerve.
- Middle layer – Capillary layer of the Choroid – supply the choroid, that supply the external part of retina.
  - 6 Short Posterior ciliary arteries – supply the choroid. The choroid then supplies the Photoreceptor cells, outer layer of retina, by diffusion.
  - 2 Long Posterior ciliary arteries – 1 on each side of the eye ball. They pass between the Sclera and the Choroid. Supply the Ciliary Body and Iris.
- Anterior Ciliary artery – anastomose with long posterior – supply the Ciliary Body and Iris.
- Anterior Choroidal artery – supply the Optic tract. Branch of ICA.
- Eyelid – supplied by branches of the Ophthalmic artery that exit the orbit and form the Superior and Inferior Palpebral arteries.
- Extraocular muscles are supplied by Muscular branches of Ophthalmic arteries.
- Outer layer – supplied by Episcleral arteries.


Flow of aqueous humor
Scleral venous sinus
Conjunctival vessels
Cornea
Iris
Scleral venous sinus
Greater arterial circle of iris
Sphincter pupillae
Dilator pupillae
Lens
Anterior ciliary vessels
Conjunctiva
Sclera
Anterior ciliary vessels—continuation of muscular arteries
Muscular branches of ophthalmic artery
Choroidal vessel
Ciliary muscle
Ciliary
Zonular fibers
Muscular artery and vein
Episcleral vessels
Vorticose vein
Optic disc
Capillary lamina of choroid
Long posterior ciliary artery
Short posterior ciliary vessels
Dural vessels
Short posterior ciliary vessels
Optic nerve (CN II)
Central retinal artery and vein
Pial vessels
Supratrochlear artery
Supra-orbital artery
Dorsal nasal artery
Anterior ciliary artery
Zygomaticofacial artery
Canals in zygomatic bone
Zygomatico-temporal artery
Ethmoidal arteries in canals in ethmoid bone
Anterior
Posterior
Long posterior ciliary artery
Central artery of retina
Middle meningeal artery
Lacrimal artery
Short posterior ciliary artery
Optic nerve (CN II)
Ophthalmic artery
Internal carotid artery

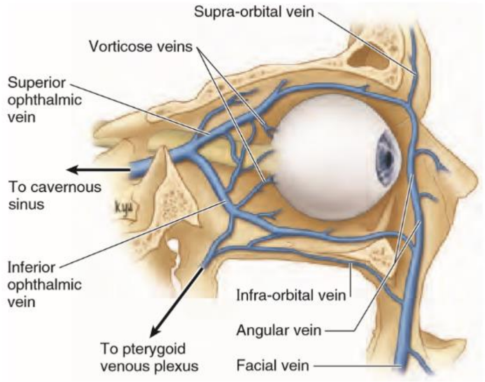
Branches of the ophthalmic artery that end out of the orbit

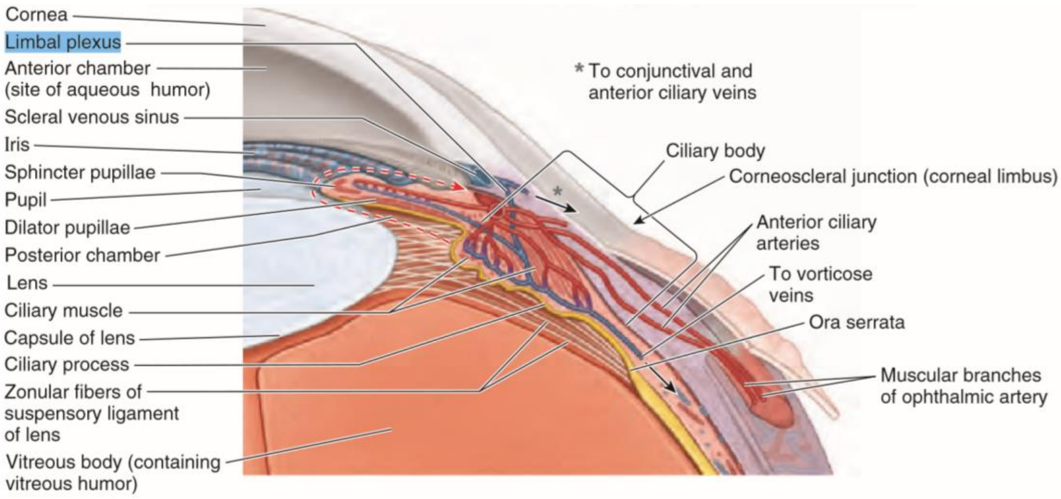


Artery	Origin	Course and Distribution
Ophthalmic	Internal carotid artery	Traverses optic foramen to reach orbital cavity
Central artery of retina	Ophthalmic artery	Pierces dural sheath of optic nerve and runs to eyeball; branches from center of optic disc; supplies optic retina (except cones and rods)
Supra-orbital		Passes superiorly and posteriorly from supra-orbital foramen to supply forehead and scalp
Supratrochlear		Passes from supra-orbital margin to forehead and scalp
Lacrimal		Passes along superior border of lateral rectus muscle to supply lacrimal gland, conjunctiva, and eyelids
Dorsal nasal		Courses along dorsal aspect of nose and supplies its surface
Short posterior ciliaries		Pierce sclera at periphery of optic nerve to supply choroid, which in turn supplies cones and rods of optic retina
Long posterior ciliaries		Pierce sclera to supply ciliary body and iris
Posterior ethmoidal		Passes through posterior ethmoidal foramen to posterior ethmoidal cells
Anterior ethmoidal		Passes through anterior ethmoidal foramen to anterior cranial fossa; supplies anterior and middle ethmoidal cells, frontal sinus, nasal cavity, and skin on dorsum of nose
Anterior ciliary	Muscular (rectus) branches of ophthalmic artery	Pierces sclera at attachments of rectus muscles and forms network in iris and ciliary body
Infra-orbital	Third part of maxillary artery	Passes along infra-orbital groove and foramen to face

Veins of the eye:

- Superior and Inferior Ophthalmic veins – pass through Superior Orbital Fissure. Join the Cavernous Sinus.
- Central vein of the Retina – drain the retina. join the Ophthalmic vein into the Cavernous Sinus.
- Vorticose veins – drain the vascular layer into the Inferior Ophthalmic vein.
- Episcleral vein – drains the outer layer of the eye.
- Scleral venous sinus – drainage of Aqueous Humour from the anterior chamber of the eye.


Supra-orbital vein
Vorticose veins
Superior ophthalmic vein
To cavernous sinus
Inferior ophthalmic vein
Infra-orbital vein
Angular vein
To pterygoid venous plexus
Facial vein


Cornea
Limbal plexus
Anterior chamber (site of aqueous humor)
Scleral venous sinus
Iris
Sphincter pupillae
Pupil
Dilator pupillae
Posterior chamber
Lens
Ciliary muscle
Capsule of lens
Ciliary process
Zonular fibers of suspensory ligament of lens
Vitreous body (containing vitreous humor)
* To conjunctival and anterior ciliary veins
*
Ciliary body
Corneoscleral junction (corneal limbus)
Anterior ciliary arteries
To vorticose veins
Ora serrata
Muscular branches of ophthalmic artery

Production, Circulation and Reabsorption of the Aqueous Humour:
(include histological structures that are not seen on the model).

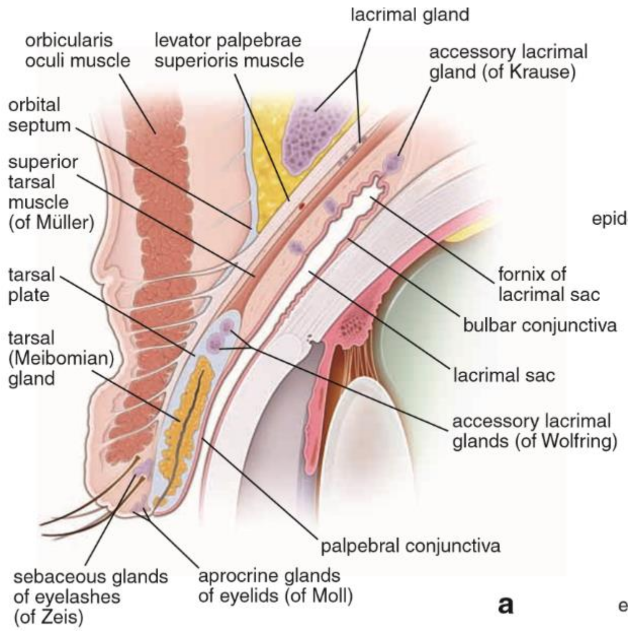
- the Aqueous Humour is the fluid that fills The anterior and posterior chambers of the eye.
  - The Posterior chamber – between the Lens and the Iris.
  - The Anterior chamber – between the Iris and the Cornea.
- Production: made by the ciliary processes of the ciliary body. It is secreted at the rim of Posterior chamber.
- Circulation: from the posterior chamber it flows through the pupillary opening into the anterior chamber.
- Drainage:
  1. at the angle between the Cornea and Iris, Iridocorneal angle, the liquid drains through a Trabecular meshwork.
  2. that meshwork drains into the Canal of Schlemm. This canal encircles the eye, and it is also called Scleral Venous Sinus (convey Aqueous Humour instead of blood). It is also called Aqueous veins.
  3. then the Limbal plexus transport the Aqueous Humour to (blood) veins in the sclera – Vorticose and Anterior Ciliary veins.

- Functions:
  1. Maintains the intraocular pressure and inflates the globe of the eye.
  2. Provides nutrition (e.g. amino acids and glucose) and anti-oxidant agents for the avascular ocular tissues – posterior part of Cornea, Trabecular meshwork and Lens.
  3. Clear waste products of the avascular ocular tissues.
  4. Contain Immunoglobulins to defend against pathogens.

- Composition:
  - 99% water.
  - Ions.
  - Proteins.
  - Ascorbate – anti-oxidant agent, protect against the radicals formed by UV light.
  - Nutrients.

Topic 28 – Demonstration of the structures involved in tear production and drainage on the orbital model

Ross 923. Moore 892.


lacrimal gland
orbicularis oculi muscle
levator palpebrae superioris muscle
accessory lacrimal gland (of Krause)
orbital septum
superior tarsal muscle (of Müller)
epid
tarsal plate
fornix of lacrimal sac
bulbar conjunctiva
tarsal (Meibomian) gland
lacrimal sac
accessory lacrimal glands (of Wolfring)
palpebral conjunctiva
sebaceous glands of eyelashes (of Zeis)
aprocrine glands of eyelids (of Moll)
a
e

- The Tears, (Latin = Lacrima), is a thin layer of liquid found on the anterior surface of the eye.
- Function:

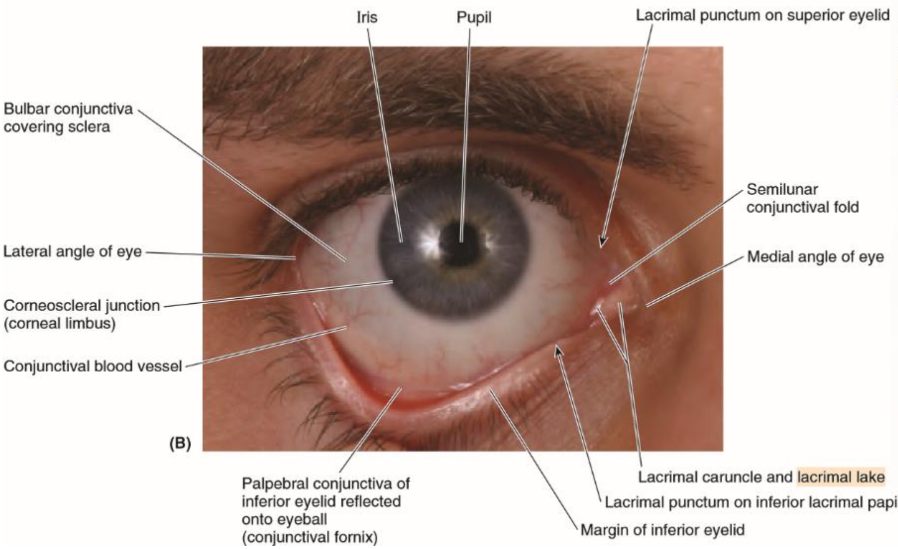
  1. Protect against substances that touch the eye, as dust, and washes them away. also Has immune molecules that protect against bacteria.
  2. Keeps the surface moist.
  3. Lubrication – enables the conjunctiva (thin layer in the inner eye-lid) to slide over the eye when the eye lid closes.
  4. Provides nutrients and oxygen from the air.
- Secretion is also effected by emotions.

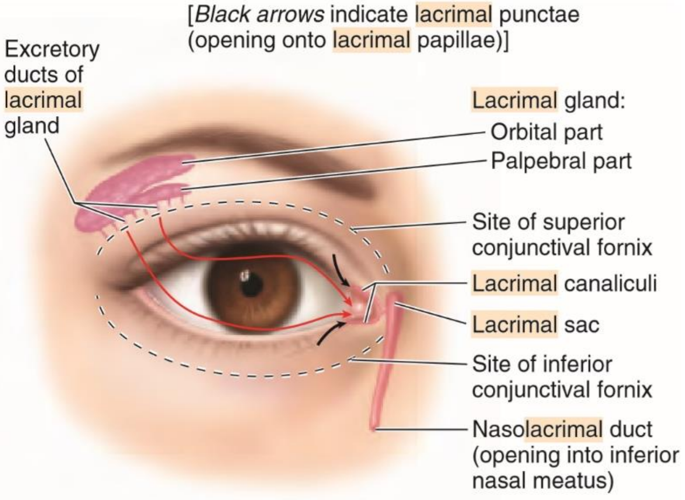
Lacrimal Gland:

- Location: in the fossa for the Lacrimal Gland, On the superior lateral part of the orbit.
- Has few lobules. Acini have columnar cells, and myoepithelial cells that assist in pushing the secretion.
- The tendon of Levator Palpebrae Superioris divide the gland into 2 parts – superior (orbital) and inferior (palpebral).
- 12 excretory ducts drain the secretion into an area at the superior part of the conjunctiva.
- Accessory Lacrimal Glands also produce the tears.
- Innervation:
  - Lacrimal nerve of the Ophthalmic branch of Trigeminal nerve. Zygomatic nerve (from the maxillary nerve) brings SNS and PNS fibers to the lacrimal nerve.
  - Parasympathetic innervation increase secretion – presynaptic PNS secretomotor fibers from the facial nerve travel through the Greater Petrosal nerve (from C.N.7). They meet the sympathetic fibers and become the nerve of Pterygoid canal and end in the pterygopalatine ganglion. From the ganglion they are carried by the zygomatic nerve to the lacrimal nerve.
  - Sympathetic innervation decrease secretion – Postsynaptic sympathetic fibers from the superior cervical ganglion on the internal carotid plexus continue as the deep petrosal nerve, join the parasympathetic fibers to form the nerve of pterygoid canal and end in the pterygopalatine ganglion. From there, Zygomatic nerve carries the fibers to the Lacrimal nerve.
- Blood supply: Lacrimal artery, branch of the Ophthalmic artery.

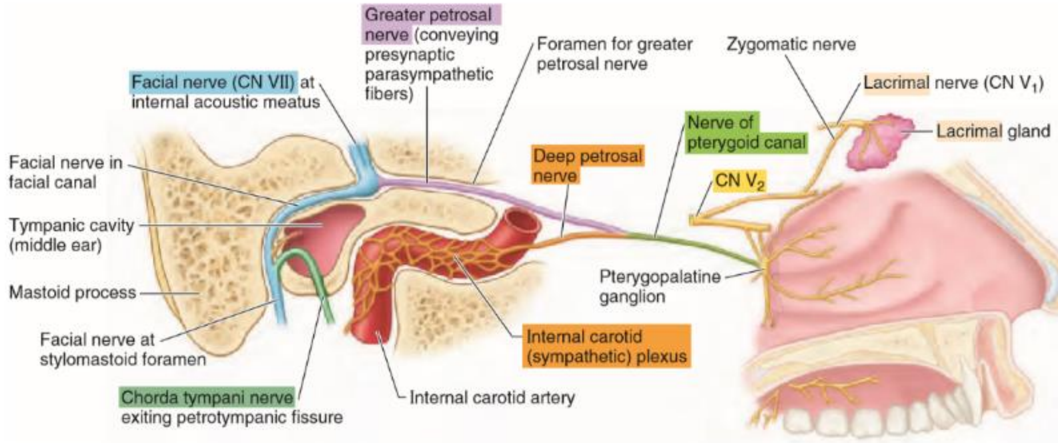
Tear drainage:

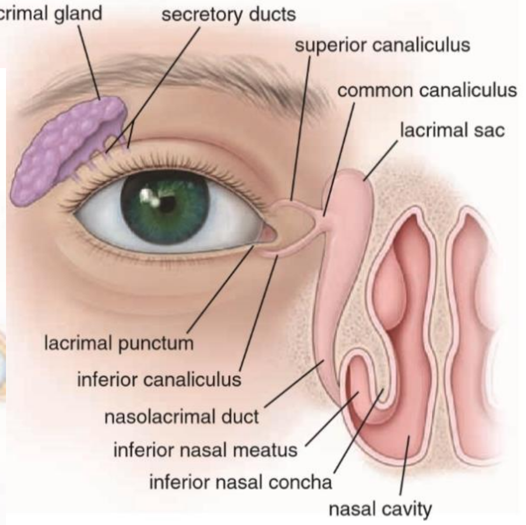
1. Tears are secreted from the Lacrimal Gland through the excretory ducts.
2. move to the medial part of the eye through the Fornix of Lacrimal ducts – 2 arches formed by the conjunctiva, that lead the tears medially (not seen on the eye), to the Lacrimal Lake found at the medial part of the eye.
3. The Lacrimal Papilla is an elevation on the inner side of eyelid, at the edge of the Lacrimal Lake. The Lacrimal Canaliculi open into the papilla. The opening of each of them is called Lacrimal Punctum.
4. The fluid Enters into superior and inferior Lacrimal Canaliculi.
5. The 2 canaliculi unite to form the Common Canaliculus.
6. The common canaliculus opens into the Lacrimal Sac – dilated part at the superior part of the lacrimal duct, found in the Lacrimal bone.
7. The nasolacrimal duct opens into the nasal cavity, at the Inferior Nasal Meatus.
8. From the nasal cavity to the nasopharynx, and eventually swallowed.


Iris
Pupil
Lacrimal punctum on superior eyelid
Bulbar conjunctiva covering sclera
Semilunar conjunctival fold
Lateral angle of eye
Medial angle of eye
Corneoscleral junction (corneal limbus)
Conjunctival blood vessel
(B)
Palpebral conjunctiva of inferior eyelid reflected onto eyeball (conjunctival fornix)
Lacrimal caruncle and lacrimal lake
Lacrimal punctum on inferior lacrimal papilla
Margin of inferior eyelid


[Black arrows indicate lacrimal punctae (opening onto lacrimal papillae)]
Excretory ducts of lacrimal gland
Lacrimal gland:
Orbital part
Palpebral part
Site of superior conjunctival fornix
Lacrimal canaliculi
Lacrimal sac
Site of inferior conjunctival fornix
Nasolacrimal duct (opening into inferior nasal meatus)

**the pink at the medial corner of the eye is the lacrimal caruncle – a rudimentary


Greater petrosal nerve (conveying presynaptic parasympathetic fibers)
Foramen for greater petrosal nerve
Zygomatic nerve
Facial nerve (CN VII) at internal acoustic meatus
Lacrimal nerve (CN V1)
Lacrimal gland
Nerve of pterygoid canal
Deep petrosal nerve
CN V2
Facial nerve in facial canal
Tympanic cavity (middle ear)
Mastoid process
Pterygopalatine ganglion
Facial nerve at stylomastoid foramen
Internal carotid (sympathetic) plexus
Chorda tympani nerve exiting petrotympanic fissure
Internal carotid artery


lacrimal gland
secretory ducts
superior canaliculus
common canaliculus
lacrimal sac
lacrimal punctum
inferior canaliculus
nasolacrimal duct
inferior nasal meatus
inferior nasal concha
nasal cavity

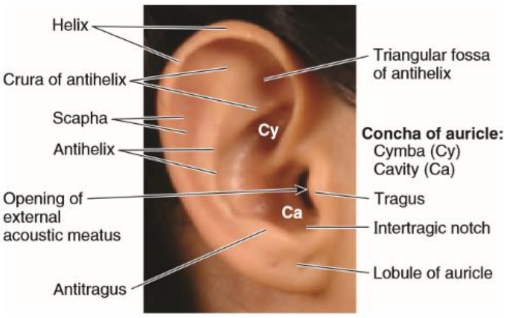
Topic 29 – Demonstration of the External and Middle Ear on the head and models. Demonstration of their position on the skull

Hain's – auditory 287, vestibular 300. Moore 966.

- The external and middle ear are parts of the auditory system. They conduct the sound from the air into the inner ear, there the sound is converted to information that reaches the brain.

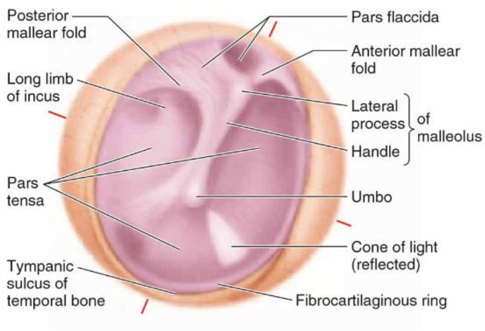
External ear:

- The Pinna – also called Auricle. extends around the external auditory meatus.
  - 2/3 of it is Made of Cartilage.
  - Captures the sound waves and channels them into the meatus.
  - Built of few structures:
    1. Helix – the surrounding rim. An elevated margin. Ends in the Crura of helix that turns posteriorly.
    2. Antihelix – parallel to the helix, but smaller and more internal.
       splits at its end into 2 Crura, to form the triangular fossa of antihelix.
    3. Scapha – depression posterior to the antihelix.
    4. Concha of auricle – 2 depressions: Cymba (superior) and Cavity, inferior, where external auditory meatus opens.
    5. Tragus – elevation above the opening of External Acoustic Meatus.
    6. Anti-tragus – elevation on the opposite side. Above the lobule. Separated from tragus by the Inter-Tragic notch.
    7. Lobule of auricle (earlobe) – fibrous tissue and fat at the inferior part of auricle. Has no cartilage.
    8. Auricular sulcus – depression behind the ear, next to the head.



  - The superior, anterior and posterior auricular muscle – less developed in human. In other animals they move the auricle to focus on sounds from specific direction.
  - Cutaneous Innervation – Great Auricular (of cervical plexus) and Auriculotemporal (V3) nerves. Little by facial and vagus nerves.
  - Blood supply – Posterior Auricular and Superficial Temporal arteries, from the ext. carotid a.
  - Lymph drainage – Superficial Parotid, Mastoid and Deep Cervical lymph nodes.

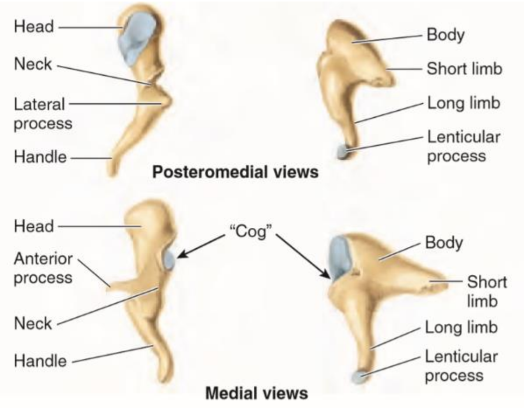
- External auditory meatus – elastic cartilage
  - A canal in the temporal bone, 2-3 cm long. The lateral third is cartilaginous.
  - Leads from the Pinna to the tympanic membrane. As sound air waves hit the tympanic membrane, the vibrations are transmitted to the Ossicles of the middle ear.
  - Ear wax (Cerumen) is produced in the cartilaginous part. Sebaceous glands are present.


Posterior mallear fold
Long limb of incus
Pars tensa
Tympanic sulcus of temporal bone
Pars flaccida
Anterior mallear fold
Lateral process
Handle
of malleolus
Umbo
Cone of light (reflected)
Fibrocartilaginous ring

- The tympanic membrane –
  - Surrounded by Fibrocartilaginous ring.
  - has 2 surfaces: one on the external ear, and one on the middle ear.
  - Cone shape, points into the middle ear. its peak – the Umbo.
  - The malleus bone binds the tympanic membrane, and receives the vibrations.
  - 2 parts: pars Fleccida – superior to the malleus process. It is thinner.
    Pars Tensa – inferior part. Thicker and responsible for the transmission of waves.
  - Innervation – external surface: Auriculotemporal nerve (V3) and C.N 10.
    internal surface: C.N. 9.

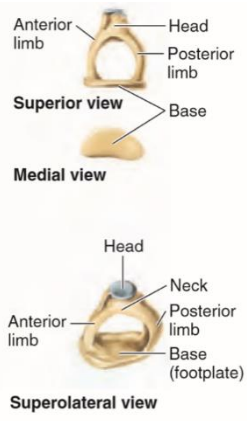
Middle ear = tympanic cavity: → Tympanic nerve / Plexus

- Air filled region inside the petrous bone. between the external and middle ear.
- The cavity is lined by mucous.
- Houses the Ossicles:
  - Conduct air vibration into the inner ear (tympanic membrane > oval window).
  - Covered by mucous membrane, but have no periosteum.
  - Make amplification of the sound wave.
  - The bones (outer to inner):
    - Malleus (hammer) – function as lever.
      1. Handle: also called Manubrium. embedded in the Tympanic Membrane, moves with it as sound wave arrives. The tendon of Tensor tympani inserts into it.
      2. Neck: lies again flaccid part of tympanic membrane. Chorda tympani passes next to it. From it an anterior and lateral processes extend.
      3. Head: found in the Epitympanic Recess. Articulates with the incus.


Head
Neck
Lateral process
Handle
Posteromedial views
Body
Short limb
Long limb
Lenticular process
Head
Anterior process
Neck
Handle
"Cog"
Body
Short limb
Long limb
Lenticular process
Medial views

(B) MALLEUS (C) INCUS

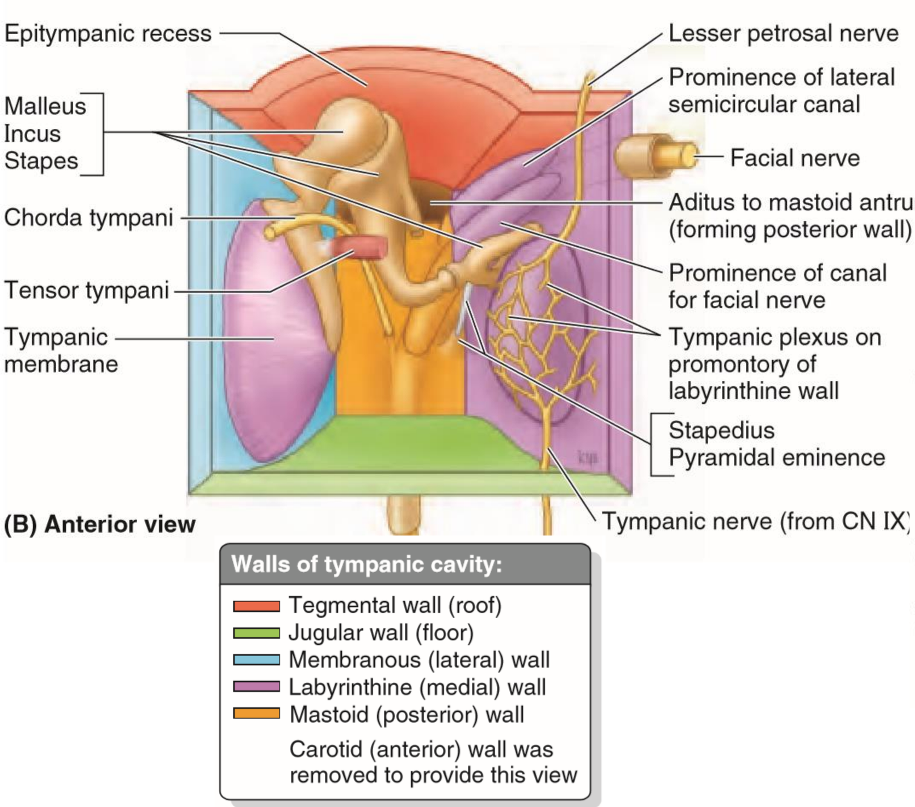
    - Incus (anvil – סדן) –
      1. Body: in the Epitympanic Recess. Articulates with the malleus.
      2. Long limb: articulates with head of stapes by the Lenticular process.
      3. Short limb: connect the posterior wall of the cavity, by a ligament.
    - Stapes (stirrups - ארכובה) – smallest bone.
      1. Head: articulates with the incus.
      2. Neck: insert point of the Stapedius muscle, that originates from the pyramidal eminence on the posterior wall.
         Middle ear reflex – in case of noise or when eating, Stapedius pulls the stapes to reduce the sound conduction. Innervated by nerve to Stapedius of facial nerve.
      3. Base: binds the margins of Oval Window. Because it is smaller than the tympanic membrane, it causes amplification of the sound wave.

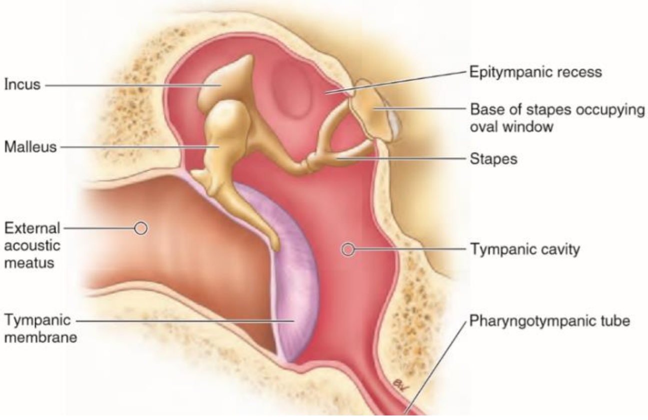

Anterior limb
Head
Posterior limb
Superior view
Base
Medial view
Head
Neck
Posterior limb
Anterior limb
Base (footplate)
Superolateral view

(D) STAPES

- The middle ear has 6 walls:
    - Roof – tegmental wall. Made by the Tegmen Tympani – thin bone that separates the middle ear and the dura mater. Can be broken by infection in the middle ear. In that case the infection might spread to the dura and cause meningitis.
    - Floor – Jugular wall. Bony part, separates the middle ear from the Internal jugular vein.
    - Lateral – Membranous wall. separates the middle ear from the external ear.
      Tympanic membrane, and above it the Epitympanic recess – space for the head of malleus.
      the Chorda Tympani passes between the malleolus and the tensor tympani.
    - Medial – Labyrinthine wall. separates the middle ear from the inner ear.
      Structures:
        1. Promontory of labyrinthine wall – bump made by cochlea. The Tympanic Plexus is on it.
        2. Oval and Round windows – entrance and exit of waves from the cochlea.
        3. Prominence of Lateral Semicircular canal and prominence of Facial canal.
    - Posterior – Mastoid wall. separates the middle ear from the mastoid air cells.
      has a small opening – the Aditus to mastoid antrum. It leads to the antrum, that leads to the mastoid air cells.
    - Anterior – Carotid wall. separates the middle ear from the carotid canal.
      At the superior part of that wall – Musculotubarian canal, that has 2 parts:
      1. opening of Pharyngotympanic Tube – also called the Auditory tube or Eustachian canal. Connect the tympanic cavity to the nasopharynx, in-order to equalize pressures of middle ear and external environment, to allow movement of the tympanic membrane. It is made of bone and cartilage, lined by mucous.
      2. Opening of the canal for Tensor Tympani – in it, the Tensor Tympani muscle passes. It inserts on the handle of malleolus and tenses the tympanic membrane when strong noise reaches the ear.

Clinical from lecture: Paracentesis – making Small opening through tympanic membrane for draining fluids in case of inflammation of middle ear. Made in the posterior-lower part, because the upper part has malleus and chorda tympani and tensor tympani tendon, Anterior part is close to carotid canal with the artery.


Epitympanic recess
Malleus
Incus
Stapes
Chorda tympani
Tensor tympani
Tympanic membrane
Lesser petrosal nerve
Prominence of lateral semicircular canal
Facial nerve
Aditus to mastoid antrum (forming posterior wall)
Prominence of canal for facial nerve
Tympanic plexus on promontory of labyrinthine wall
Stapedius
Pyramidal eminence
Tympanic nerve (from CN IX)
(B) Anterior view
Walls of tympanic cavity:
🟥 Tegmental wall (roof)
🟩 Jugular wall (floor)
🟦 Membranous (lateral) wall
🟪 Labyrinthine (medial) wall
🟧 Mastoid (posterior) wall
Carotid (anterior) wall was removed to provide this view


Incus
Malleus
External acoustic meatus
Tympanic membrane
Epitympanic recess
Base of stapes occupying oval window
Stapes
Tympanic cavity
Pharyngotympanic tube

→ What is vestibular choclear reflex

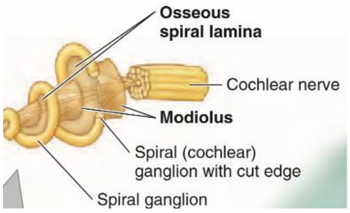
Topic 30 – Demonstration of the Inner Ear on the ear model and bone preparation. Demonstration of their position on the internal cranial base

Hain's – auditory 287, vestibular 300. Moore 966.

- The inner ear contains the Vestibulocochlear organ – responsible for hearing and balance.
  it is a bony structure called Otic Capsule (the bone itself, harder than the surrounding bone).
  It contains membranous part that floats in a fluid called Perilymph.
  The membranous part itself contains different fluid – the Endolymph.
- Perilymph – similar to extracellular fluid (low K ion). The endolymph – similar to intracellular fluid (high K).

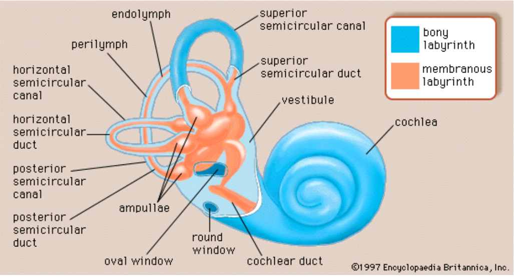
Bony labyrinth:

- Location – in the Petrous part of the Temporal bone.
- The bony labyrinth is the space inside Otic Capsule. Filled with perilymph and has few parts:
  1. Cochlea: responsible for hearing. Points anteromedially in the petrous bone.
     - It is attached to the vestibule, and from it the spiral canal turns 2.5, around a bony axis called Modiolus. The basal (first) turn of the spiral, creates the promontory on the labyrinthine wall of the tympanic cavity.
     - The Modiolus is cone shaped, and contains blood vessels and the Spiral Ganglion that receive input from hair cells and form the Cochlear nerve.
     - The cochlear duct connects the cochlea to the subarachnoid space through the Cochlear Aqueduct.
     - The round window is found at its end, closed by the Secondary Tympanic membrane.



  2. Vestibule of Bony Labyrinth: responsible for balance.
     - Contains 2 membranous parts – the utricle and saccule.
     - has the Oval window, from it sound waves travel into the Cochlea.
     - On the other side it continues to the Semicircular canals.
     - The Vestibular Aqueduct contains the Endolymphatic duct. The aqueduct connects the vestibule to the posterior cranial fossa, opens posteromedial to the internal acoustic meatus, there the Endolymphatic sac is found – it stores excess endolymph and drains it to the subarachnoid space. blood vessels pass next to it.

  3. Semicircular canals: responsible for balance.
     - Posterior to the vestibule. Points posterolaterally in the petrous bone.
     - Composed of 3 semi-circular canals: posterior, lateral (horizontal), anterior (superior) – 1 for each plane. Bony ampulla is found at 1 end of the canal.
     - Each forms 2/3 of a circle.
     - The posterior and anterior canals have one common opening, so there are 5 exits from the vestibule into the Semicircular canals.
     - The ampulla is found in one end of each canal (so total 3 ampullas). It houses the sensory unit – the crista.


endolymph
superior semicircular canal
bony labyrinth
membranous labyrinth
perilymph
superior semicircular duct
horizontal semicircular canal
vestibule
horizontal semicircular duct
cochlea
posterior semicircular canal
ampullae
posterior semicircular duct
round window
oval window
cochlear duct
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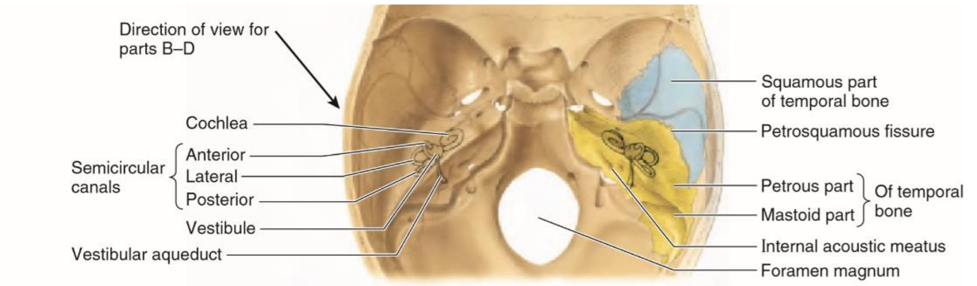
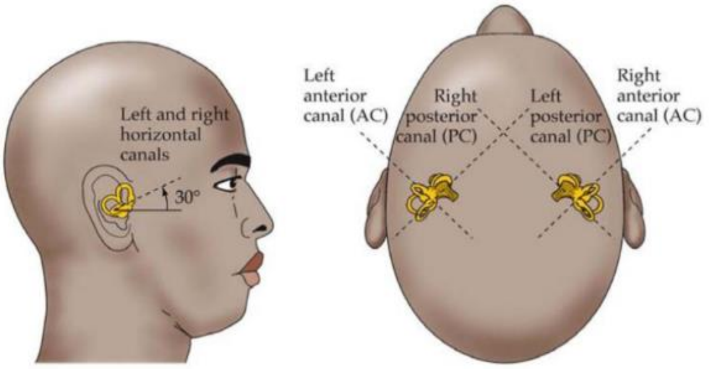

Direction of view for parts B–D
Cochlea
Semicircular canals
Anterior
Lateral
Posterior
Vestibule
Vestibular aqueduct
Squamous part of temporal bone
Petrosquamous fissure
Petrous part
Mastoid part
Of temporal bone
Internal acoustic meatus
Foramen magnum

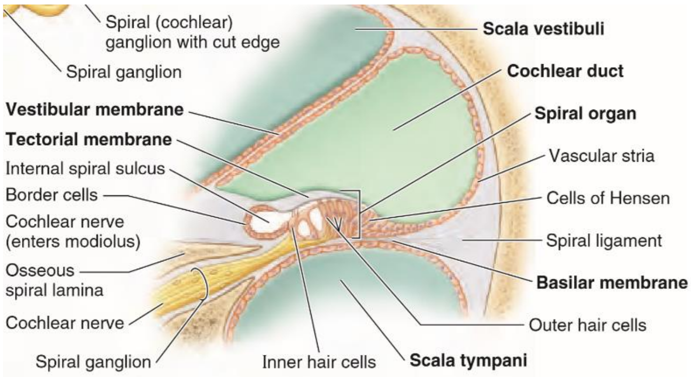
Position on the internal cranial base:

- The posterior canal points posterolaterally, along the axis of the petrous part of temporal bone, as shown in the picture.
  The cochlea points anteromedially.

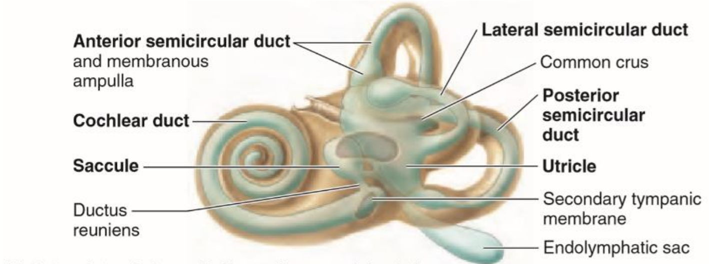

Left and right horizontal canals
30°
Left anterior canal (AC)
Right posterior canal (PC)
Left posterior canal (PC)
Right anterior canal (AC)

Membranous labyrinth:

- Inside the bony labyrinth.
- Filled with endolymph, which is different from the perilymph.
- The cells that are responsible for the actual sensing are found in it.
  1. Cochlear duct:
     - In it found the Organ of Corti, that is responsible for sensing the sound.
     - The ducts forms spiral tube, bound by the Spiral Ligament to the bony structure – cochlear canal.
     - It separates the perilymph filled cavity into 2 parts – Scala vestibule and Scala tympani.
       - ✈ Scala vestibule is above the cochlear duct, separated by the Vestibular (Reissner's) membrane.
       - ✈ Scala tympani is below the cochlear duct, separated by the Basilar membrane, on which the Organ of Corti is found. In it – inner (1 row) and outer hair cells (3-5 rows) are found.
     - Sound waves travel from the oval window > enters the Scala vestibule > at the Helicotrema (connection of the 2 Scala) pass to the Scala tympani > end in the Round window.
     - The Tectorial membrane is found in the cochlear duct. Action potential is made as sound wave compress the hair cells between the basilar and tectorial membranes.
     - The cochlear duct is considered as Scala media, because it Is in the middle. Its borders:
       - ✈ Medial: osseus spiral lamina.
       - ✈ Lateral: upper part of the spiral ligament. stria vascularis – contains many capillies producing endolymph for scala media.
       - ✈ Superior: Vestibular (Reissner's) membrane.
       - ✈ Inferior: Basilar membrane.


Spiral (cochlear) ganglion with cut edge
Spiral ganglion
Scala vestibuli
Cochlear duct
Vestibular membrane
Spiral organ
Tectorial membrane
Vascular stria
Internal spiral sulcus
Border cells
Cells of Hensen
Cochlear nerve (enters modiolus)
Spiral ligament
Osseous spiral lamina
Basilar membrane
Cochlear nerve
Outer hair cells
Spiral ganglion
Inner hair cells
Scala tympani

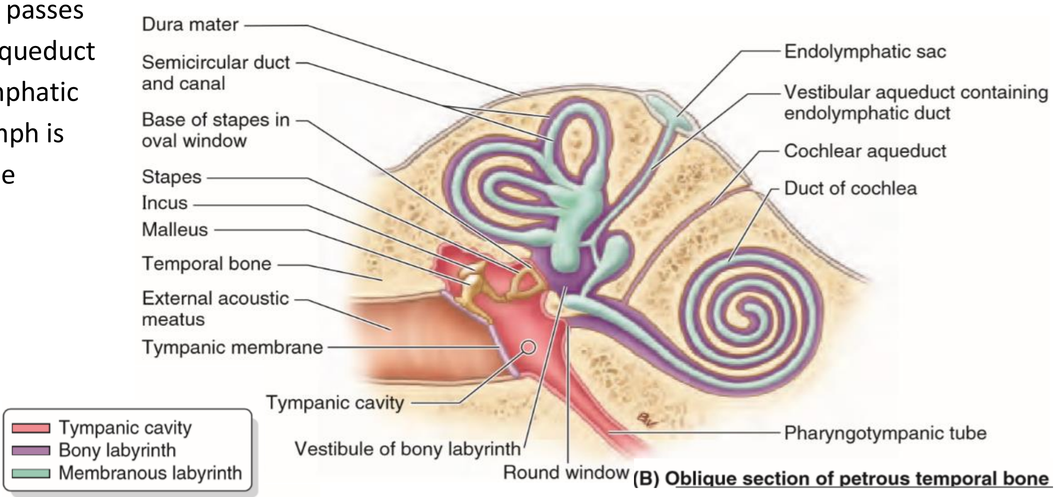
2. 3 Semicircular ducts:
    - Open into the Utricle.
    - Contain 3 'Crista' – the sensory unit, one for each duct. It senses axial acceleration. It is found in the Ampulla – dilated part of the duct.


Anterior semicircular duct and membranous ampulla
Cochlear duct
Saccule
Ductus reuniens
Lateral semicircular duct
Common crus
Posterior semicircular duct
Utricle
Secondary tympanic membrane
Endolymphatic sac

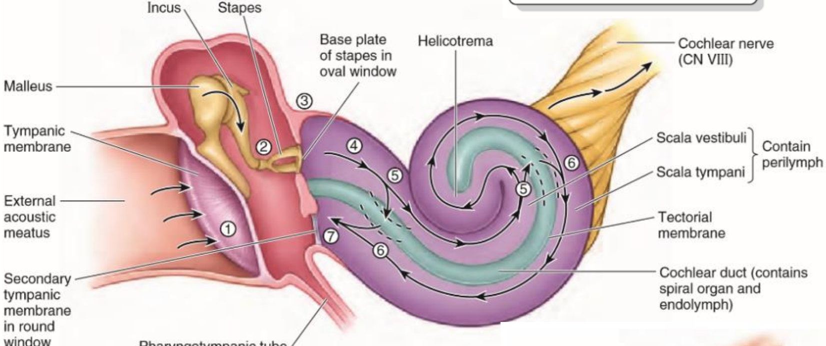
(C) Anterolateral view of left membranous labyrinth (through transparent otic capsule)

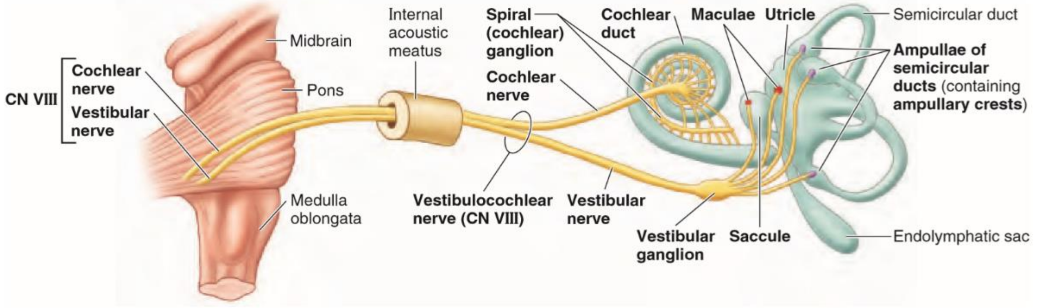
3. Saccule and utricle:
    - The organ that senses static balance, the Macula, is found in each of them. Fibers from it form the vestibular ganglia, that continue into the Vestibulocochlear nerve.
    - The Macula of Saccule and Utricle are perpendicular to each other.
    - The Saccule connects to the cochlear duct by the Ductus Reuniens.
    - The Utricle connects to the saccule and to the semi-circular ducts.
    - The Saccule and utricle are connected by the Utriculosaccular duct.

- The Internal Acoustic Meatus – on the petrous bone. Exit point of the Vestibulocochlear nerve, Facial nerve, Intermediate nerve and Labyrinthine artery.
- The endolymphatic duct passes through the vestibular aqueduct and ends in the endolymphatic sac, from which endolymph is stored and drained to the subarachnoid space.


Dura mater
Semicircular duct and canal
Base of stapes in oval window
Stapes
Incus
Malleus
Temporal bone
External acoustic meatus
Tympanic membrane
Tympanic cavity
Vestibule of bony labyrinth
Round window
Endolymphatic sac
Vestibular aqueduct containing endolymphatic duct
Cochlear aqueduct
Duct of cochlea
Pharyngotympanic tube
🟥 Tympanic cavity
🟪 Bony labyrinth
🟩 Membranous labyrinth

(B) Oblique section of petrous temporal bone


Incus
Stapes
Malleus
Tympanic membrane
External acoustic meatus
Secondary tympanic membrane in round window
Pharyngotympanic tube
Base plate of stapes in oval window
Helicotrema
Cochlear nerve (CN VIII)
Scala vestibuli
Scala tympani
Contain perilymph
Tectorial membrane
Cochlear duct (contains spiral organ and endolymph)
①
②
③
④
⑤
⑥
⑦

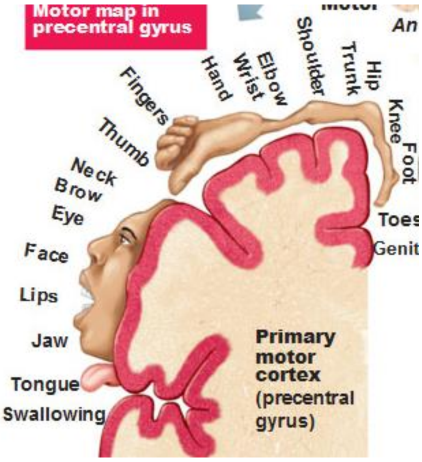

CN VIII
Cochlear nerve
Vestibular nerve
Midbrain
Pons
Medulla oblongata
Internal acoustic meatus
Vestibulocochlear nerve (CN VIII)
Spiral (cochlear) ganglion
Cochlear nerve
Cochlear duct
Vestibular nerve
Vestibular ganglion
Maculae
Utricle
Saccule
Semicircular duct
Ampullae of semicircular ducts (containing ampullary crests)
Endolymphatic sac

Group B

Topic 1 – Demonstration of the origin and course of the Corticospinal tract

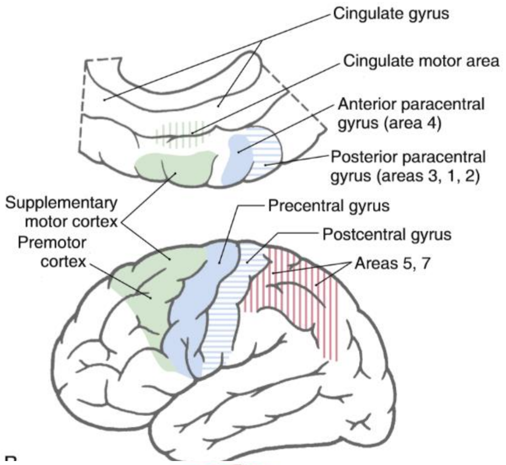
Hain's 339

- Corticospinal tract – a descending somatomotor tract.
- This is the Pyramidal pathway – it passes in the pyramid (part of medulla).
- Function: activates voluntary movement of flexor and extensors muscles of **contralateral** side.
- Divided into 2 – anterior and lateral corticospinal tracts:
  - Lateral corticospinal: Crosses at the pyramidal decussation = motor decussation. So the fibers from the left motor cortex effect the right side of the body.
  - Anterior corticospinal: don't cross at the pyramid. Remain ipsilateral until it decussates at the level of exit from spinal cord.
- Importance of blood supply to each segment – if the artery that supply a certain segment is occluded, the fibers passing in it will not function.
- Path: Cortex > Corona Radiata > Posterior limb of Internal Capsule > Crus Cerebri > basilar pons > medullary pyramid > spinal cord > spinal nerve > muscle.


Motor map in precentral gyrus
Shoulder
Trunk
Hip
Elbow
Wrist
Hand
Fingers
Thumb
Neck
Brow
Eye
Face
Lips
Jaw
Tongue
Swallowing
Knee
Foot
Toes
Genit
Primary motor cortex (precentral gyrus)

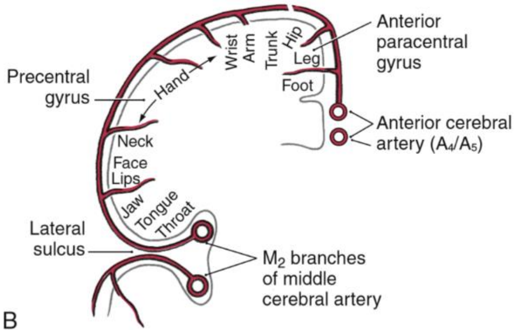
1. In Cortex:

- The fibers originate from few places on the cortex, always from Betz cells that are located in layer 5:
  - Most fibers originate at the precentral gyrus – the primary motor cortex, Brodmann area 4. on it, the motor homunculus is represented. the fibers origin from somatotopically arranged areas, that send fibers to the corresponding organs. organs that are shown as bigger on the homunculus, are controlled more accurately.
  - Fibers also come from the anterior paracentral gyrus, which is also part of Brodmann area 4, and from the premotor and supplementary motor cortices, in area 6.
  - Postcentral gyrus – primary sensory cortex, Brodmann areas 3,1,2.
  - Superior parietal lobule – Brodmann areas 5,7.
  - Cingulate gyrus.


Cingulate gyrus
Cingulate motor area
Anterior paracentral gyrus (area 4)
Posterior paracentral gyrus (areas 3, 1, 2)
Supplementary motor cortex
Premotor cortex
Precentral gyrus
Postcentral gyrus
Areas 5, 7

*Supplied by anterior and middle cerebral arteries. damage to the arteries cause dysfunction of the corresponding organ.

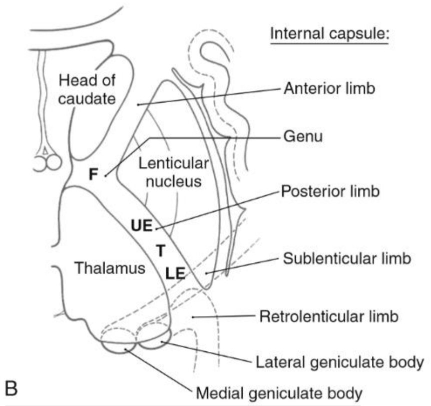
- Lower limb – Supplied by branches of anterior cerebral artery – A4, A5, specifically Callosomarginal artery.
- Head, Upper limb and Trunk – Supplied by branches of middle cerebral artery – M4, mainly rolandic and prerolandic branches.


Precentral gyrus
Hand
Wrist
Arm
Trunk
Hip
Leg
Foot
Anterior paracentral gyrus
Anterior cerebral artery (A₄/A₅)
Neck
Face
Lips
Jaw
Tongue
Throat
Lateral sulcus
M₂ branches of middle cerebral artery
B

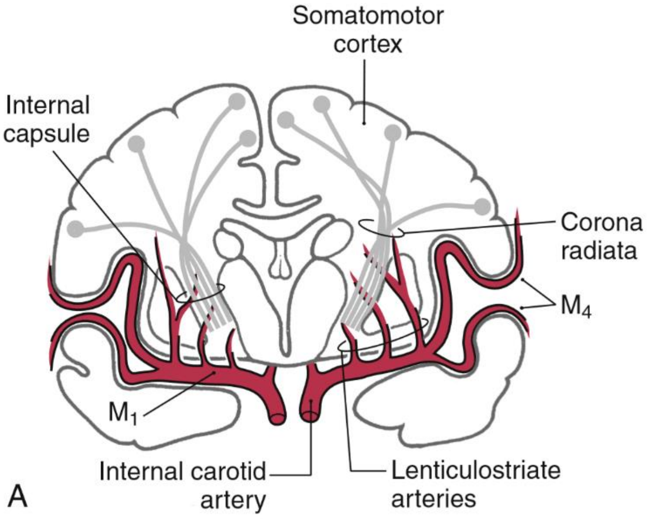
2. Pass through the Corona Radiata – crown shaped fibers from cortex that enter the internal capsule.

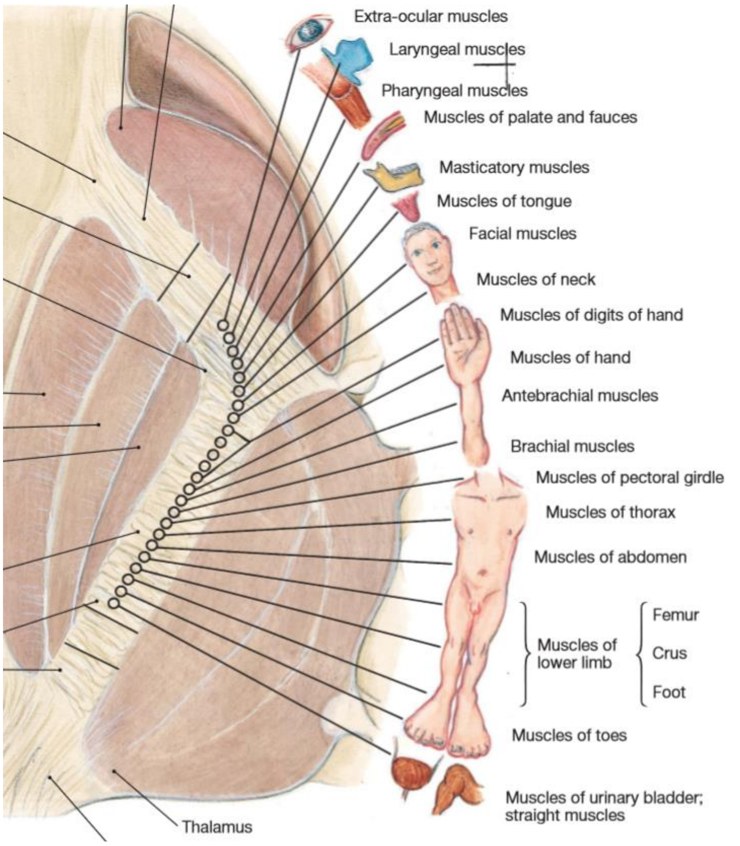
3. Posterior limb of Internal Capsule:

- Fibers pass through the posterior limb of the internal capsule.
- They are somatotopically arranged:
  - Axons that end in higher body parts – pass more anteriorly in the Internal Capsule.
  - Axons that end in lower body parts – pass more posteriorly in the Internal Capsule.
- Fibers to the face end in the brain stem, there they go through the cranial nerves to muscles of face. They pass in the genu as corticonuclear (corticobulbar) tract that ends in the nuclei of brain stem.
  upper half of the face is controlled by the 2 hemispheres,
  lower half of the face is controlled mainly by the contralateral hemisphere.


Internal capsule:
Head of caudate
Anterior limb
Genu
F
Lenticular nucleus
Posterior limb
UE
T
Thalamus
LE
Sublenticular limb
Retrolenticular limb
Lateral geniculate body
B
Medial geniculate body

F – face, UE – arm–upper extremity,
T – trunk, LE – leg–lower extremity.

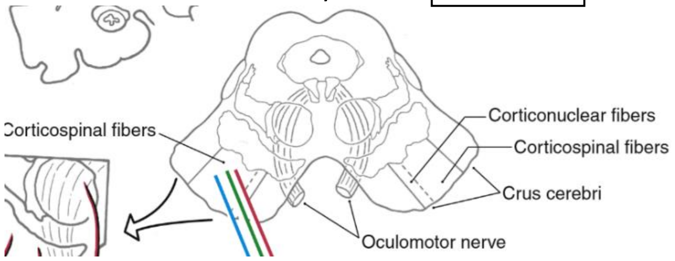

Somatomotor cortex
Internal capsule
Corona radiata
M4
M1
Internal carotid artery
Lenticulostriate arteries
A


Extra-ocular muscles
Laryngeal muscles
Pharyngeal muscles
Muscles of palate and fauces
Masticatory muscles
Muscles of tongue
Facial muscles
Muscles of neck
Muscles of digits of hand
Muscles of hand
Antebrachial muscles
Brachial muscles
Muscles of pectoral girdle
Muscles of thorax
Muscles of abdomen
Muscles of lower limb
Femur
Crus
Foot
Muscles of toes
Muscles of urinary bladder; straight muscles
Thalamus

4. Midbrain:

- Pass through the middle third of the Crus Cerebri.
  - Upper parts of the body pass in the medial part.
  - Lower parts of the body pass in the lateral part.
- Blood supply of the medial two thirds of the crus cerebri originate from:
  1. Paramedian branches of P1. Paramedian branches = branches that enter directly after branching, without circling that part of brain.
  2. posterior communicating artery.

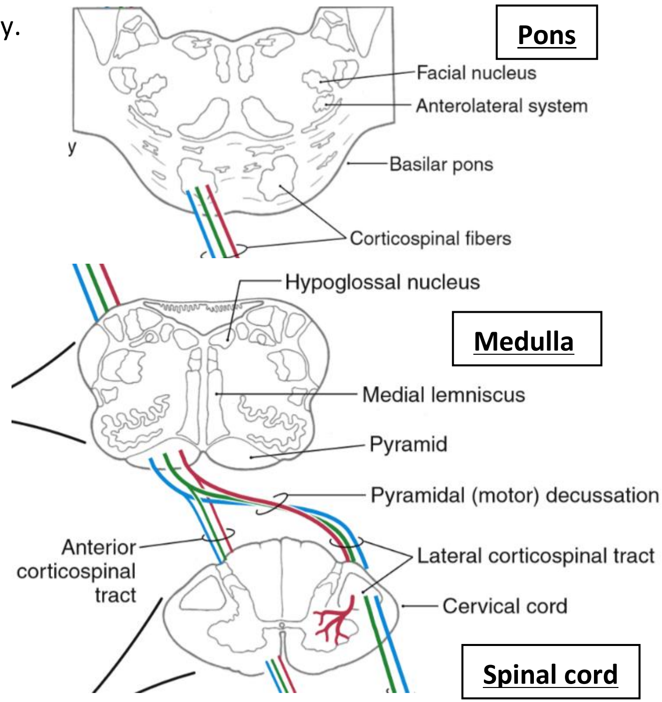
Midbrain


Corticospinal fibers
Corticonuclear fibers
Corticospinal fibers
Crus cerebri
Oculomotor nerve

5. Pons:

- Fibers pass in the basilar part, between the basilar pontine nuclei, and give collateral fibers to these nuclei.

- Blood supply: Paramedian branches of the basilar artery.


Pons
Facial nucleus
Anterolateral system
Basilar pons
Corticospinal fibers
Hypoglossal nucleus
Medulla
Medial lemniscus
Pyramid
Pyramidal (motor) decussation
Anterior corticospinal tract
Lateral corticospinal tract
Cervical cord
Spinal cord

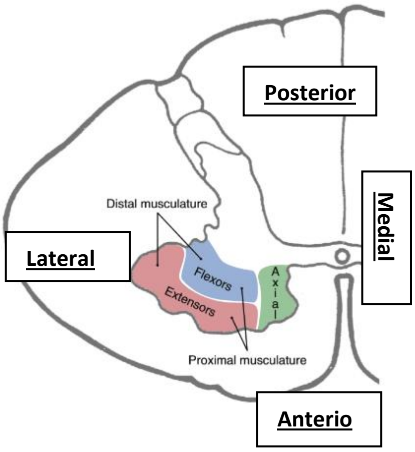
6. Medulla:

- Pass in the medullary pyramid.
  - Fibers of Upper parts of body pass medially.
  - Fibers of Lower parts of the body pass laterally.
- Blood supply: anterior spinal artery.

7. Spinal cord – white matter:

- Lateral corticospinal tract – At the medullary-spinal junction, 90% of the fibers cross in the motor decussation, also called pyramid decussation. It passes in the Lateral funiculus.
  - Fibers of Upper parts of body pass in the upper part of decussation.
  - Fibers of Lower parts of the body pass in the lower part of decussation.
- Anterior corticospinal tract – 10% of the fibers. Do not cross. Pass in the anterior funiculus. They decussate in the ventral white commissure, at the level of the spinal cord in which they end.

8. Spinal cord – grey matter –

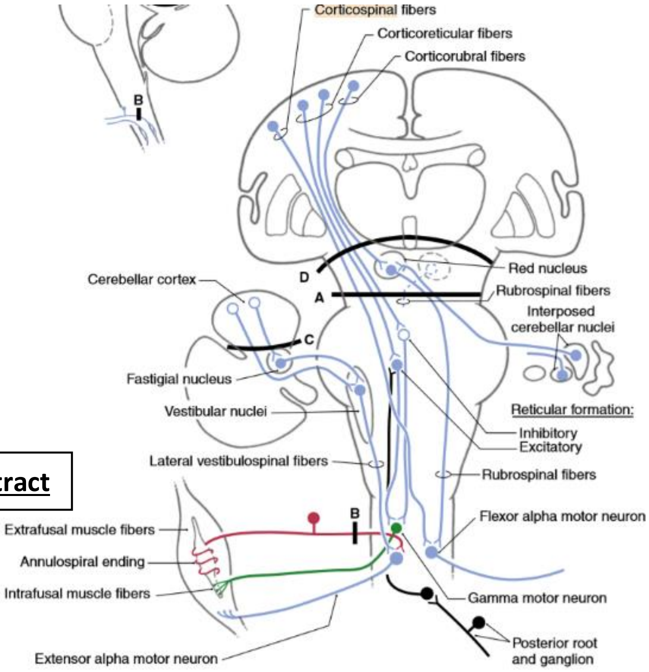

Posterior
Medial
Distal musculature
Lateral
Flexors
Extensors
Axial
Proximal musculature
Anterio

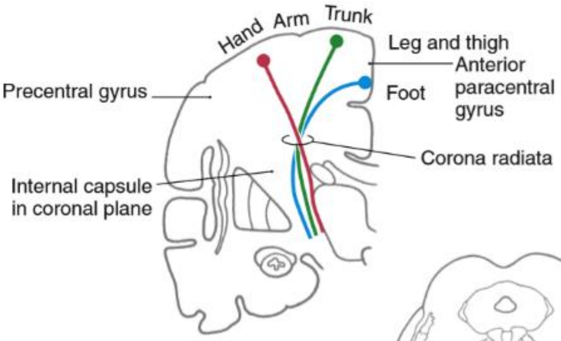
- fibers from frontal lobe end mainly in the intermediate zone and anterior horn – laminae 8-9. These fibers innervate the motor neurons.
- Cell bodies of motor neurons are distributed in the gray matter –
  - Medial-lateral axis – cell bodies of motor neurons that innervate distal muscles are lateral, and those that stimulate proximal muscles are medial. trunk muscles are located most medially.
  - Anterior-posterior axis – cell bodies of motor neurons that innervate flexors are posterior, and extensors are anterior.
- Fibers from parietal lobe end mainly in the posterior horn – laminae 4-6.
- Most fibers terminate in spinal cord enlargement – cervical and lumbar – to enter the limbs.

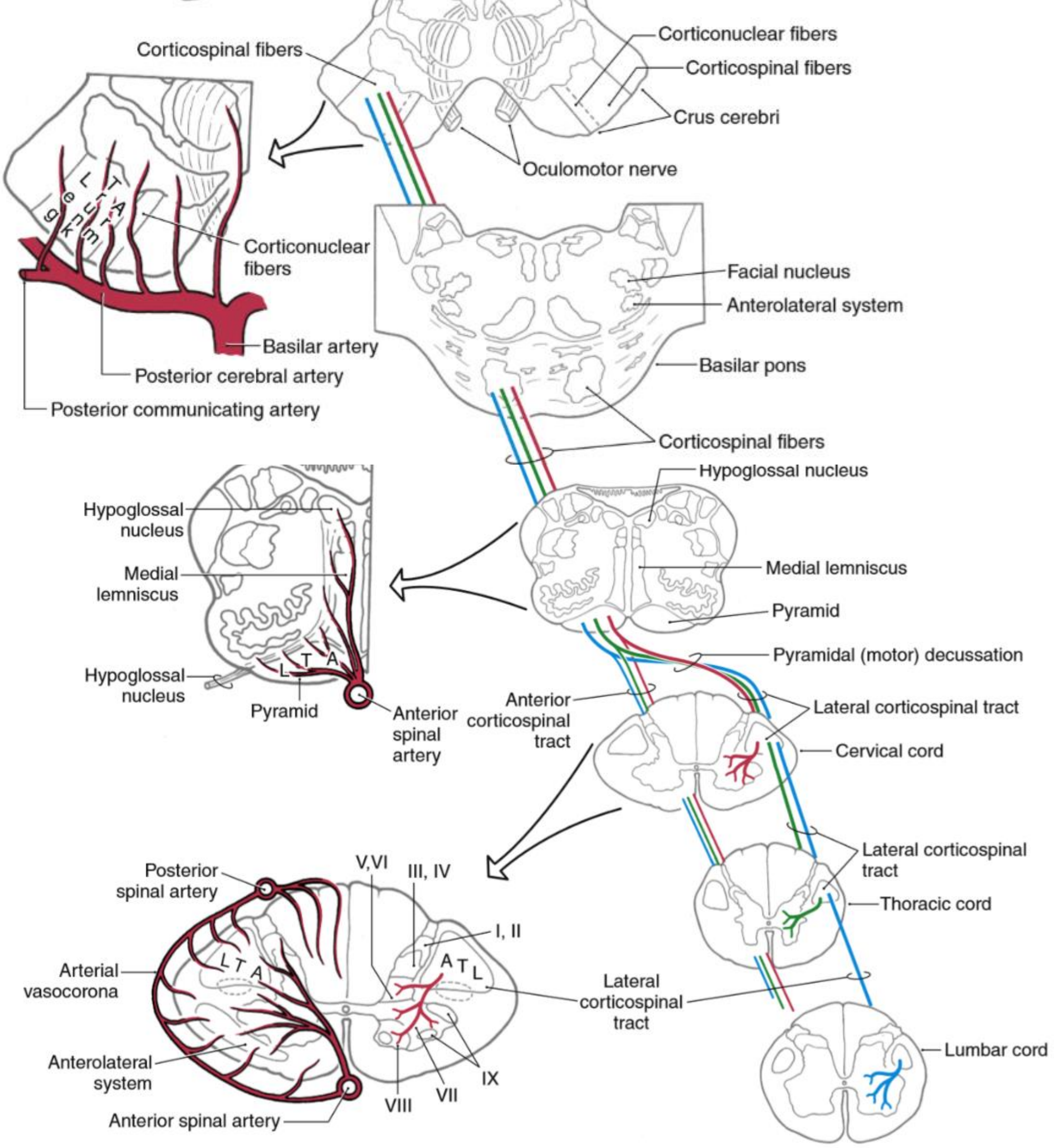
8. Spinal nerve to the Effector:

- The motor neuron in the spinal cord sends axon in the spinal nerve that reaches the muscle, which is the effector cell.
- These are skeletal muscles that control motion and posture of the body.
- **They are not considered as part of the pathway**, but this is the purpose of the pathway's activity.

Corticospinal tract


Corticospinal fibers
Corticoreticular fibers
Corticorubral fibers
B
Red nucleus
D
Rubrospinal fibers
A
Cerebellar cortex
Interposed cerebellar nuclei
C
Fastigial nucleus
Vestibular nuclei
Reticular formation:
Inhibitory
Excitatory
Lateral vestibulospinal fibers
Rubrospinal fibers
B
Flexor alpha motor neuron
Extrafusal muscle fibers
Annulospiral ending
Intrafusal muscle fibers
Gamma motor neuron
Posterior root and ganglion
Extensor alpha motor neuron

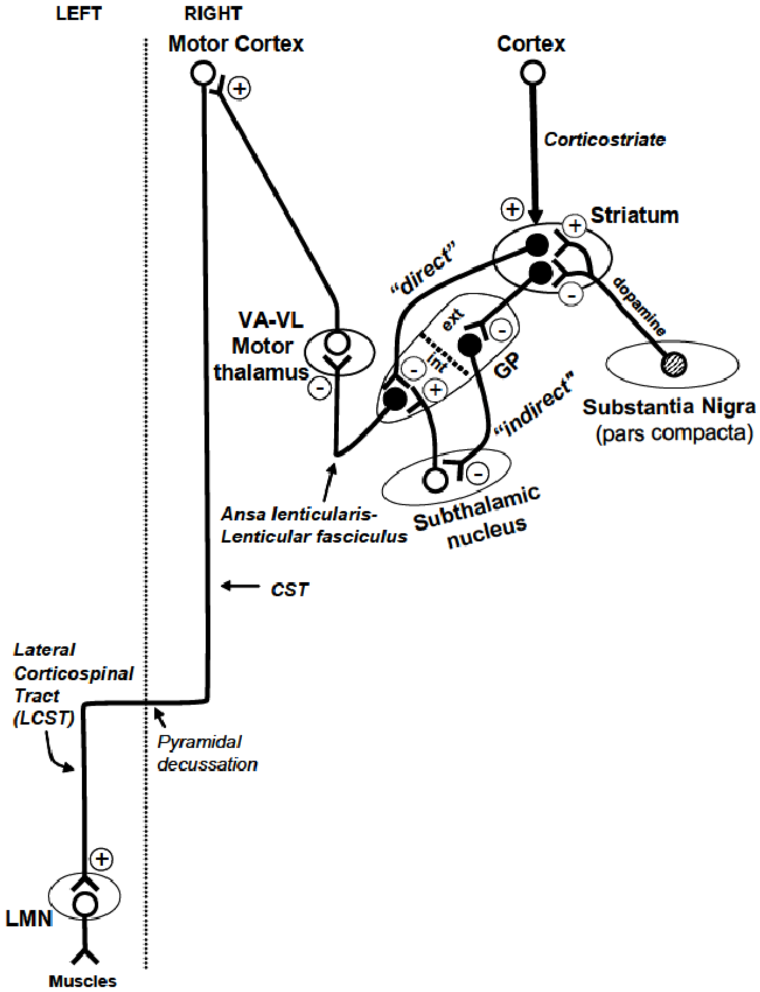

Hand
Arm
Trunk
Leg and thigh
Anterior paracentral gyrus
Foot
Precentral gyrus
Corona radiata
Internal capsule in coronal plane


Corticospinal fibers
Corticonuclear fibers
Corticospinal fibers
Crus cerebri
Oculomotor nerve
L
T
A
Leg
Trunk
Arm
Corticonuclear fibers
Basilar artery
Posterior cerebral artery
Posterior communicating artery
Facial nucleus
Anterolateral system
Basilar pons
Corticospinal fibers
Hypoglossal nucleus
Hypoglossal nucleus
Medial lemniscus
Medial lemniscus
Pyramid
Hypoglossal nucleus
L
T
A
Pyramid
Anterior spinal artery
Pyramidal (motor) decussation
Anterior corticospinal tract
Lateral corticospinal tract
Cervical cord
Lateral corticospinal tract
Thoracic cord
Posterior spinal artery
V,VI
III, IV
I, II
L
T
A
A
T
L
Arterial vasocorona
Lateral corticospinal tract
Anterolateral system
IX
VII
VIII
Anterior spinal artery
Lumbar cord

Topic 2 – Demonstration of the structures related to the somatomotor innervation. (excluding the pyramidal tract) of the trunk and extremities.

Hain's 339.

- The somatomotor innervation of the body it controlled by the primary motor cortex. From there, actions are initiated and planned together with the other cortical area and with nuclei of the brain – thalamus and nuclei of the basal ganglia.

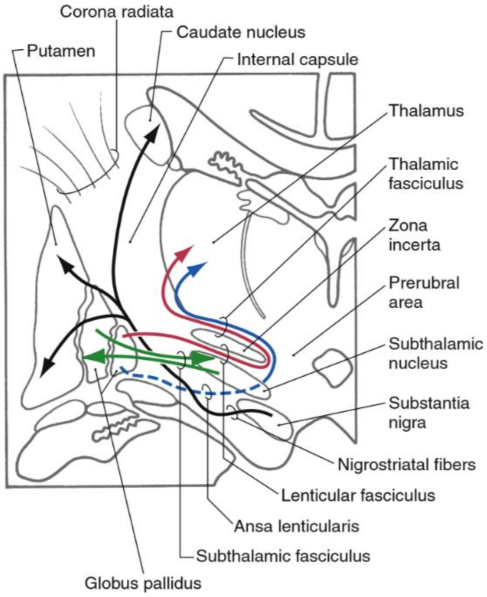

LEFT
RIGHT
Motor Cortex
Cortex
Corticostriate
Striatum
"direct"
dopamine
ext
int
GP
VA-VL
Motor
thalamus
Substantia Nigra
(pars compacta)
"indirect"
Ansa lenticularis-
Lenticular fasciculus
Subthalamic
nucleus
CST
Lateral
Corticospinal
Tract
(LCST)
Pyramidal
decussation
LMN
Muscles

- The normal state is inhibition of action. This inhibition is done by the internal Globus pallidus on the thalamic motor nuclei – Ventral anterior (VA) and Ventral lateral (VL).
  these thalamic are excitatory. They induce cortex to initiate activity of the corticospinal tract.
  To induce movement, the inhibition should be removed, By neurons in the cortex that activate the striatum. The striatum inhibits the internal Globus pallidus.
- In the cortex, the motor neurons are found in layer 5, and they are called Betz cells.
- The cortical areas that participate in the pathways
  - Mainly the primary motor cortex – precentral gyrus, Brodmann area 4.
  - Premotor and supplementary motor cortices – superior and middle frontal gyri, Brodmann area 6.

  - Areas on the parietal lobe – postcentral gyrus, Brodmann area 3, 2, 1, and superior parietal lobule – Brodmann areas 5 and 7.
- There are 2 pathways –
  1. The direct pathway – initiates action. It cancels the inhibition by internal Globus pallidus. Thus the the excitatory impulse for movement increase and the motor activity begins.
     - Cortex > Stimulations from cortex to striatum > Internal Globus pallidus > thalamus > Cortex > Corticospinal track.
  2. The indirect pathway – inhibits action. It increases the inhibition of internal Globus pallidus
     - Cortex activates the striatum to inhibit the external Globus pallidus.
     - External Globus normally Inhibit the subthalamus.
     - When subthalamus is activated – it activates the internal Globus pallidus, thus increasing its inhibitory effect on the thalamus, thus inhibiting the motor activity.
     - To sum it up – the cortex increases the activity of subthalamus (by removing the inhibition of external Globuls pallidus) thus in increases the inhibition of thalamus by increasing the activity of internal Globus pallidus.

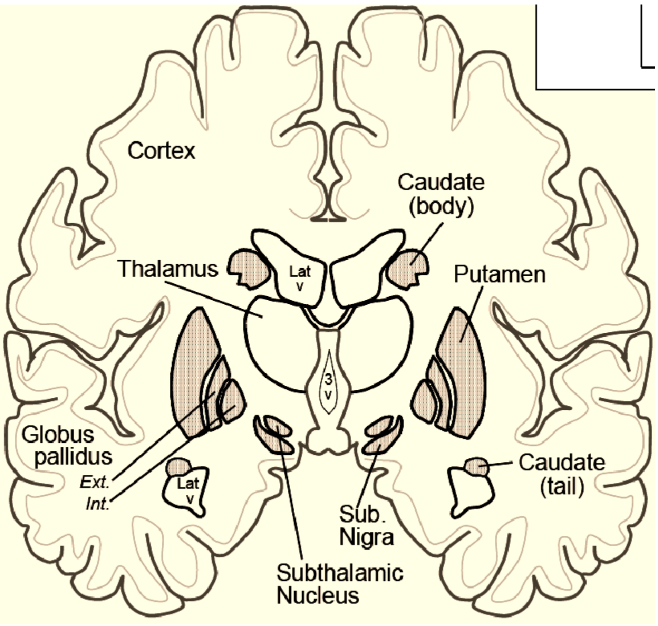
- There are 2 aditional inputs that invert this order.
  - Some neurons in the striatum release Ach. They inhibit the direct pathway and activate the indirect – thus decrease the motor activity.
  - Neurons in the compact part of substantia nigra release dopamine. They activate the direct pathway and inhibit the indirect – thus increase motor activity. Damaged in Parkinson's disease that causes tremor and decrease the motor activity.

- Structures involved –
  - Striatum – also called corpus striatum. includes the caudate nucleus and the putamen, which are part of the basal ganglia. They receive input from the cortex and activate or inhibit the direct and indirect pathways.
  - Globus pallidus – also part of the vassal ganglia. It is divided to external and internal parts, that inhibit motor activity. Inputs – striatum, subthalamus.
  - Lentiform nucleus – the name for the putamen and Globus pallidus together.
  - Subthalamic nucleus – above the substantia nigra. Inferior to thalamus and lenticular fasciculus. Inhibits motor activity. inputs: inhibitory, by the external Globus pallidus.
    Output: excitatory, to internal Globus pallidus.
  - Red nucleus – Located in the midbrain adjacent to the cerebral aqueduct and substantia nigra. It communicates with the cortex and involved in activation of flexor muscles. the reticular system also communicates with the cortex and is responsible for the extensor muscles.
  - Cerebellum – including the cerebellar peduncles through which the fibers pass, and the cerebellar nuclei. The



cerebellum is responsible for integration of information required for movement and balance. It also enables fine movement. More details in the topic of cerebellum.

- Lenticular fascicle and ansa lenticularis – are the two largest bundles of efferent fibers exiting the basal nuclei. They merge to form the thalamic fasciculus. They send fibers from internal Globus pallidus to thalamus (VA and VL nuclei).
  The lenticular fascicle pass superior to the subthalamus, and ansa reticularis pass inferior to it.
- Nuclei of the Pons – called pontine nuclei. Located in the basilar pons and receive input from the ipsilateral cerebral cortex (corticopontine fibers). They give the pontocerebellar fibers – enter the cerebellum through the middle cerebellar peduncle. into The pontocerebellum – the lateral area of the cerebellum, that includes the vestibulocerebellum and spinocerebellum, and is in charge of planning and controlling fine movement.
- Inferior Olivary nucleus – located in the medullar, under the Olive.
  It communicates mainly with the pontocerebellum through the restiform body (part of the inferior cerebellar peduncle).



Topic 3 – Demonstration of the Dorsal Column-Medial Lemniscal System (DCMLS)

Hain's 226

- Ascending tract. Give somatosensory information of proprioception and fine touch. These fibers are considered as Large Fibers – The fiber types are 1a, 1b and 2, which means they are thick fibers with thick myelin, and their conduction velocity is high.
  - Proprioception – information about body position, comes from Muscle Spindle and Golgi tendon organs. These fibers are A-alpha fibers.
  - Fine touch – comes from Mechanoreceptors on skin and internal organs. These fibers are A-beta fibers.
- Information from head, face, oral and nasal cavities passes through the trigeminal system.
- Pathway: organ > spinal nerve > dorsal root ganglion > posterior spinal cord, cuneate and gracile fasciculi > cuneate and gracile tubercle and nuclei of medulla > internal arcuate fibers form the medial lemniscus > pons and mid brain > VPL of thalamus > posterior limb of internal capsule > somatosensory cortex.

1. Organ:

- Nerve endings in organs, tendons and muscle. These nerves are the peripheral processes of the cell bodies.

2. Dorsal Root Ganglion (DRG):

- The location of the cell body of the 1st order neurons. It sends peripheral fibers to the innervated organ (through the spinal nerve), and central fiber to the gray matter of spinal cord.
- The central fibers of the DCMLS are larger than these of the pain and crud touch. They enter the dorsal horn more medially.

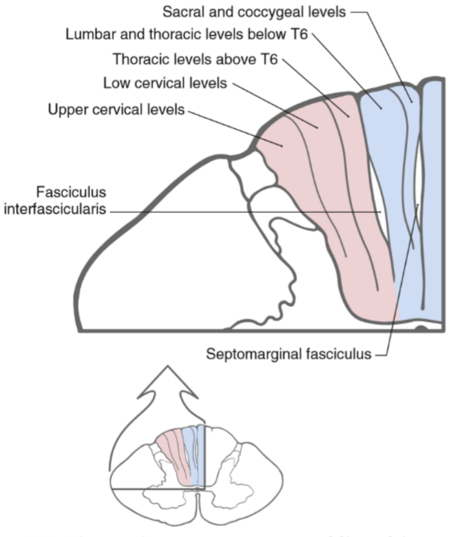
3. gray matter of spinal cord:

- The central fibers give ascending and descending fibers. Some are part of the spinal reflexes, and some are part of the ascending tract to the brain, through the gracile and cuneate fasciculi, together called the dorsal (posterior) column.

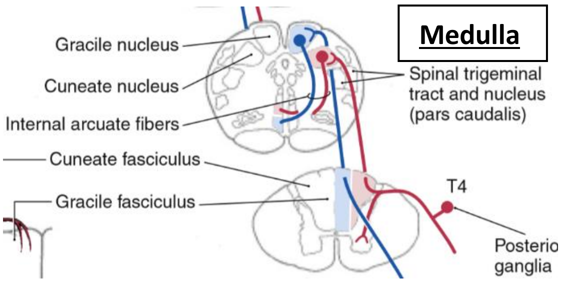
4. white matter of spinal cord:

- Fibers ascend through the dorsal column, in the Posterior Funiculus of spinal cord.
- In the dorsal column, the fibers are arranged topographically: fibers from lower parts of the body are more medial, and fibers from upper parts of the body are more lateral.
  - Gracile fasciculus – formed by fibers from sacral levels up to the level of T6. Receives information from lower limb, sacral, lumbar, and lower thoracic levels.
    Fibers from sacral level are more medial, and from T6 level are more lateral.
  - Cuneate fasciculus – Fibers from T6 up to cervical level. Receives information from upper limb, upper thoracic and cervical levels.
  - Again, lower fibers are more medial.
- Blood supply – posterior spinal artery.

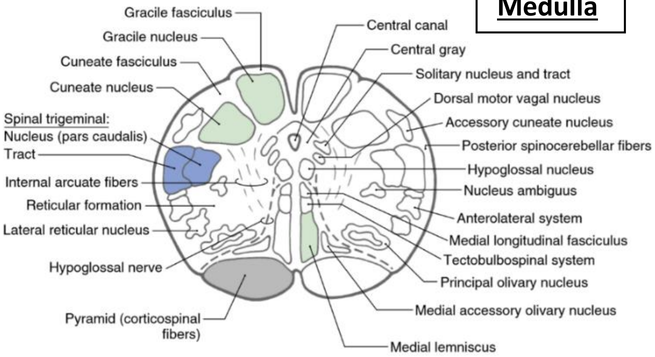
Gracile – blue, medial.
Cuneate – pink, lateral.


Sacral and coccygeal levels
Lumbar and thoracic levels below T6
Thoracic levels above T6
Low cervical levels
Upper cervical levels
Fasciculus interfascicularis
Septomarginal fasciculus

5. Medulla:


Medulla
Gracile nucleus
Cuneate nucleus
Internal arcuate fibers
Cuneate fasciculus
Gracile fasciculus
Spinal trigeminal tract and nucleus (pars caudalis)
T4
Posterio ganglia

- In the medulla, Posterior Column nuclei are formed – the Gracile and Cuneate nuclei, at the end of gracile and cuneate fasciculi, are called gracile and cuneate tubercle.
- The nuclei contain the 2nd order neurons. They also receive input from the cortex and midbrain, that modify the sensory information arriving to them.
- From the nuclei, the fibers pass anteriorly and cross to the **contralateral side**, through the **Internal Arcuate Fibers**. The crossing is called Sensory Decussation.
- Then fibers ascend as the **Medial Lemniscus** on the opposite side, anterior and medial.
    - Fibers from Cuneate nucleus are posterior.
    - Fibers from Gracile nucleus are anterior.
- Blood supply – Anterior Spinal artery and Basilar artery.

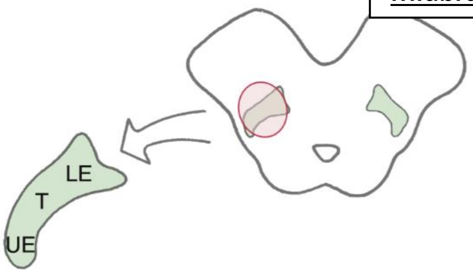

Medulla
Gracile fasciculus
Gracile nucleus
Cuneate fasciculus
Cuneate nucleus
Spinal trigeminal:
Nucleus (pars caudalis)
Tract
Internal arcuate fibers
Reticular formation
Lateral reticular nucleus
Hypoglossal nerve
Pyramid (corticospinal fibers)
Central canal
Central gray
Solitary nucleus and tract
Dorsal motor vagal nucleus
Accessory cuneate nucleus
Posterior spinocerebellar fibers
Hypoglossal nucleus
Nucleus ambiguus
Anterolateral system
Medial longitudinal fasciculus
Tectobulbospinal system
Principal olivary nucleus
Medial accessory olivary nucleus
Medial lemniscus

6. Pons:

- Medial lemniscus rotates as it ascends.
    - Upper limb is more medial.
    - Lower limb is more lateral.

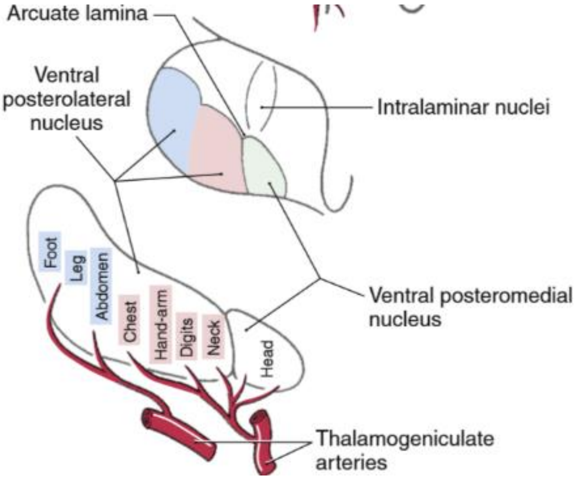
7. Midbrain:

- The Medial Lemniscus passes lateral to the red nucleus.
- From here information continues to the thalamus.


Midbrain

8. Thalamus:

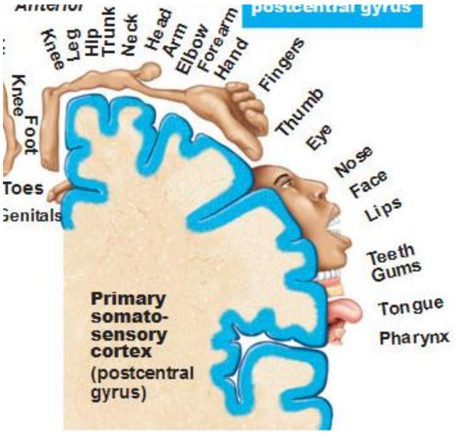
- Fibers from midbrain end in the Ventral Posterior nucleus, at the caudal part of thalamus. This is the location of 3rd neurons of this path way.
- that nucleus is divided into 2, separated by Arcuate Lamina:
    - Ventral PosteroLateral nucleus (VPL) – receives the input from Medial Lemniscus – information from the body. in it, information from cuneate nucleus is more medial.
    - Ventral PosteroMedial nucleus (VPM) – receives input from trigeminothalamic tract, that is responsible for proprioception and fine touch sensation from the head.
- Other thalamic nuclei also receive information from the medial lemniscus.
- The part of the VPL that belong to information of trunk and limbs is involved in 2 pathways:
    - Thalamocortical – sends the information of DCMLS to the cortex.
    - Local circuit interneurons – receive information from the cortex, that modify the Thalamocortical path.


Arcuate lamina
Ventral posterolateral nucleus
Intralaminar nuclei
Foot
Leg
Abdomen
Chest
Hand-arm
Digits
Neck
Head
Ventral posteromedial nucleus
Thalamogeniculate arteries

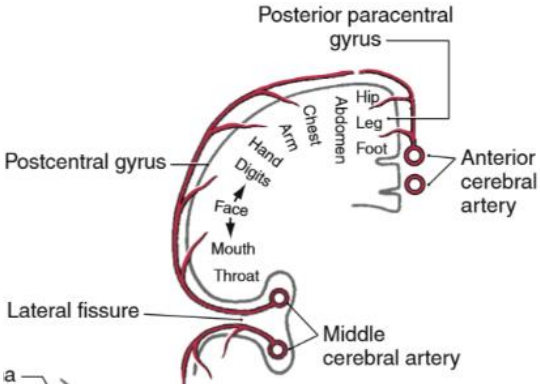
9. Internal Capsule:

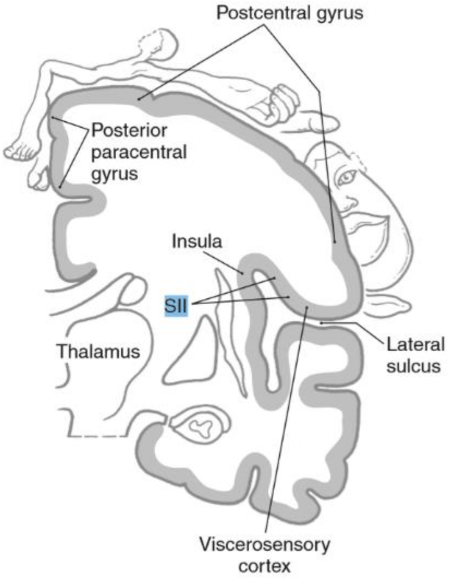
- Fibers pass in the posterior limb of the internal capsule. These fibers ascend through the Superior thalamic radiation.

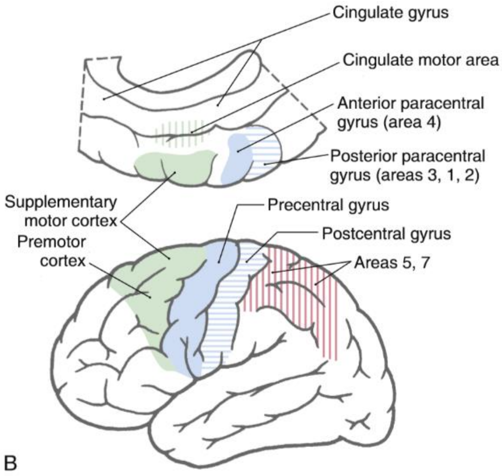
10. Cortex:

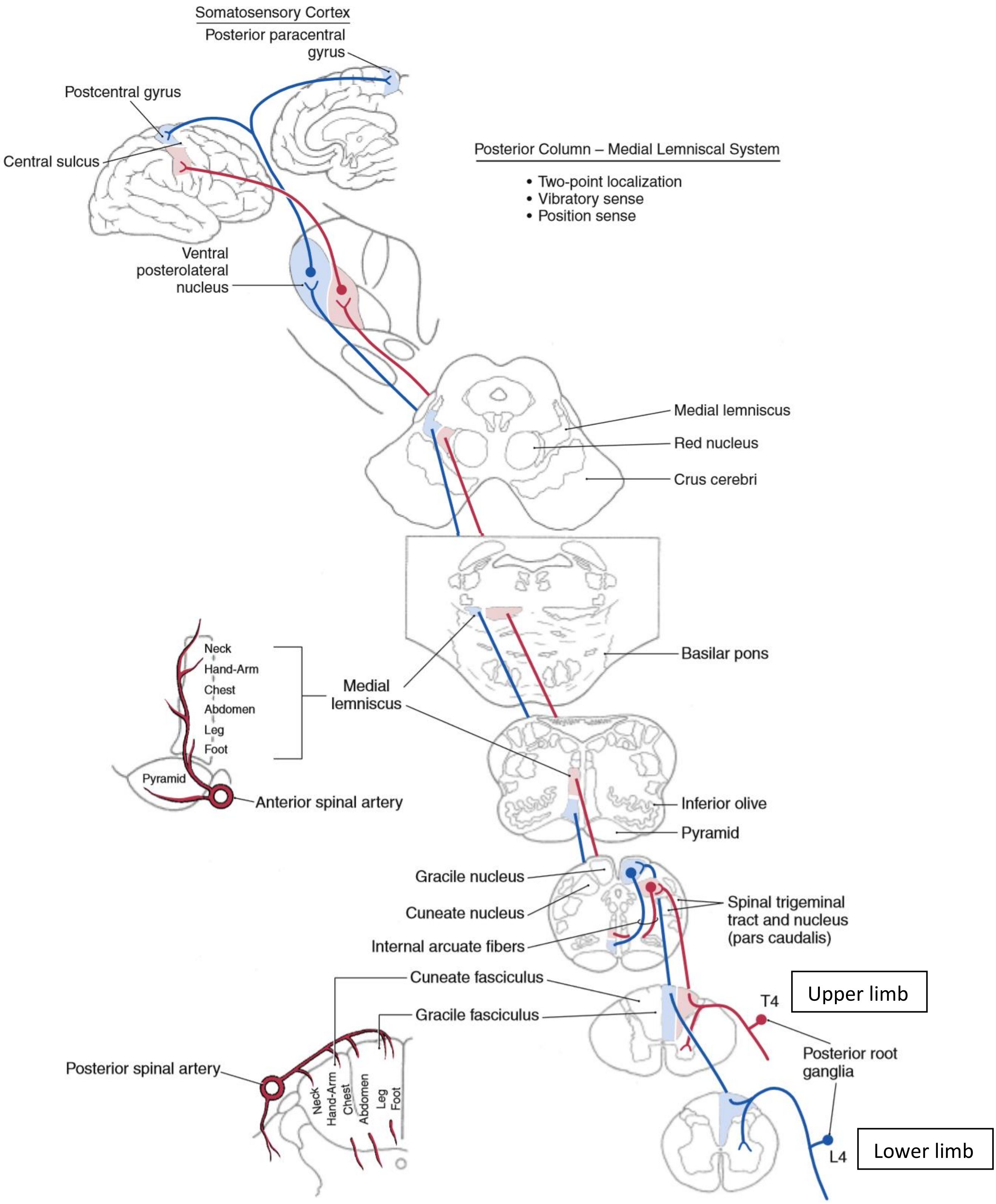

Anterior
postcentral gyrus
Knee
Leg
Hip
Trunk
Neck
Head
Arm
Elbow
Forearm
Hand
Fingers
Thumb
Eye
Nose
Face
Lips
Teeth
Gums
Tongue
Pharynx
Knee
Foot
Toes
enitals
Primary somato-sensory cortex (postcentral gyrus)

- Axons from VPL end in the primary somatosensory cortex, on the postcentral gyrus. These are Brodmann areas 3, 1, 2.
- The homunculus is represented on the gyrus.
  - Regions with high density of receptors, as hand and lips, are represented on larger areas of the cortex. They give more accurate information.
  - Regions with smaller density of receptors, as the back, are represented on smaller areas of the cortex. They give less accurate information.
  - The face is represented on the inferior part.
  - The upper limb is represented on the middle part.
  - The head, trunk and hip are represented on the superior part.
  - The lower limb and genitalia are represented on the posterior paracentral gyrus, on the medial surface. It is the posterior part of the paracentral lobule.
- Other connections of thalamus and cortex (not important):
  - Secondary somatosensory cortex (SII), found inside the lateral sulcus, receive info from ventral posterior inferior nucleus (VPI).
  - Areas 5 and 7, posterior to the postcentral gyrus, receive information from the Pulvinar and lateral posterior (LP) group of Thalamus.
- Blood supply – Anterior and Middle cerebral arteries.


Posterior paracentral gyrus
Postcentral gyrus
Hip
Leg
Foot
Abdomen
Chest
Arm
Hand
Digits
Face
Mouth
Throat
Anterior cerebral artery
Lateral fissure
Middle cerebral artery
a


Postcentral gyrus
Posterior paracentral gyrus
Insula
SII
Thalamus
Lateral sulcus
Viscerosensory cortex


Cingulate gyrus
Cingulate motor area
Anterior paracentral gyrus (area 4)
Posterior paracentral gyrus (areas 3, 1, 2)
Supplementary motor cortex
Premotor cortex
Precentral gyrus
Postcentral gyrus
Areas 5, 7
B


Somatosensory Cortex
Posterior paracentral gyrus
Postcentral gyrus
Central sulcus
Posterior Column – Medial Lemniscal System
• Two-point localization
• Vibratory sense
• Position sense
Ventral posterolateral nucleus
Medial lemniscus
Red nucleus
Crus cerebri
Basilar pons
Neck
Hand-Arm
Chest
Abdomen
Leg
Foot
Medial lemniscus
Pyramid
Anterior spinal artery
Inferior olive
Pyramid
Gracile nucleus
Cuneate nucleus
Spinal trigeminal tract and nucleus (pars caudalis)
Internal arcuate fibers
Cuneate fasciculus
Gracile fasciculus
T4
Upper limb
Posterior root ganglia
Posterior spinal artery
Neck
Hand-Arm
Chest
Abdomen
Leg
Foot
L4
Lower limb

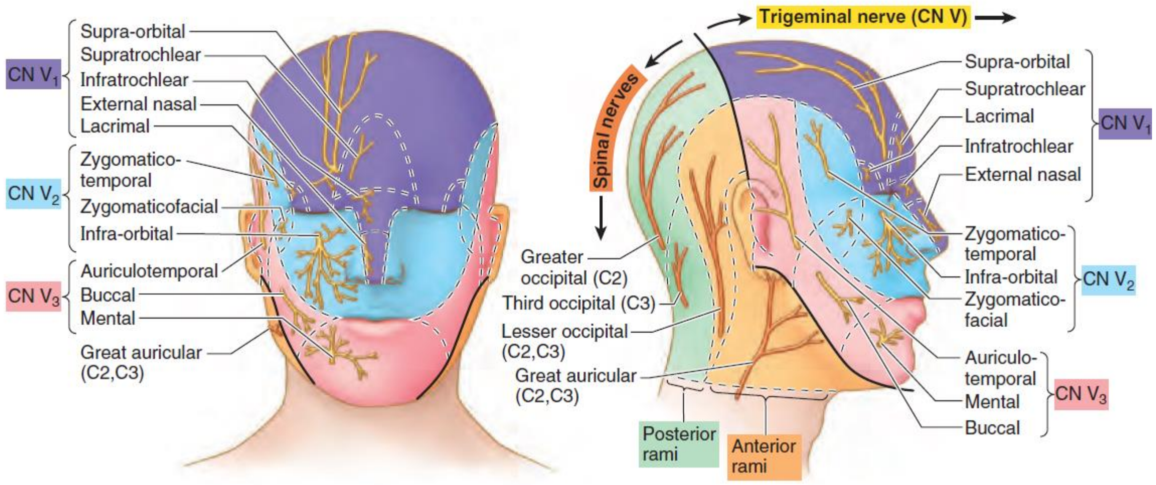
Topic 4 – Demonstration of the structures related to the somatosensory innervation of the head and neck (excluding the cervical plexus).

Hain's 234, 250. Moore 851.

- **Trigeminal System** – gives sensory information from the head and neck.
- Fine touch and proprioception from the head and face, nasal and oral cavities.
- Functions: receive the information of pain, thermal and discriminative sensations, and proprioception, from the following:
  1. Face – including cornea and conjunctiva.
  2. head – including nasal mucosa, teeth, tongue. Together with C.N. 7, 9, 10.

First order neurons –

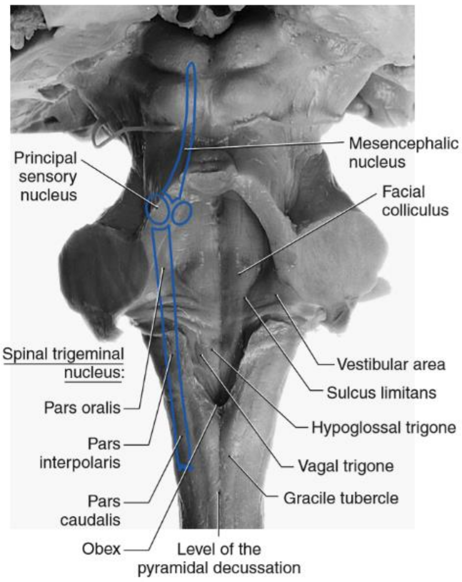
- The information is transmitted to the brain by the trigeminal nerve, which is the nerve of the 1st pharyngeal arch.
  - The cell bodies of the nerve are found in the trigeminal ganglion and in the mesencephalic trigeminal nucleus.
  - Fibers of these cell bodies enter the brain through the large sensory root in the middle of pons and then the fibers ascend and descend.
  - Ascending fibers enter the principle sensory nucleus and descending fibers form the spinal tract of trigeminal nerve and terminate in the spinal trigeminal nucleus.
- Additional information is given by cranial nerves 7, 9 and 10 from the area behind the ear. the cervical nerves supply the posterior part of the head and the neck.
- Distribution of the 3 main trigeminal branches (their branches rea not required):
  - Ophthalmic nerve – passes through the superior orbital fissure.
  - Maxillary nerve – passes through the foramen Rotundum.
  - Mandibular nerve – passes through the foramen Ovale.


CN V_1
Supra-orbital
Supratrochlear
Infratrochlear
External nasal
Lacrimal
CN V_2
Zygomatico-temporal
Zygomaticofacial
Infra-orbital
CN V_3
Auriculotemporal
Buccal
Mental
Great auricular (C2,C3)
Trigeminal nerve (CN V)
Spinal nerves
Greater occipital (C2)
Third occipital (C3)
Lesser occipital (C2,C3)
Great auricular (C2,C3)
Posterior rami
Anterior rami
Supra-orbital
Supratrochlear
Lacrimal
Infratrochlear
External nasal
CN V_1
Zygomatico-temporal
Infra-orbital
Zygomatico-facial
CN V_2
Auriculo-temporal
Mental
Buccal
CN V_3

Anterior view

Lateral view

Second order neurons – Trigeminal sensory nuclei – SE. in the brain stem.

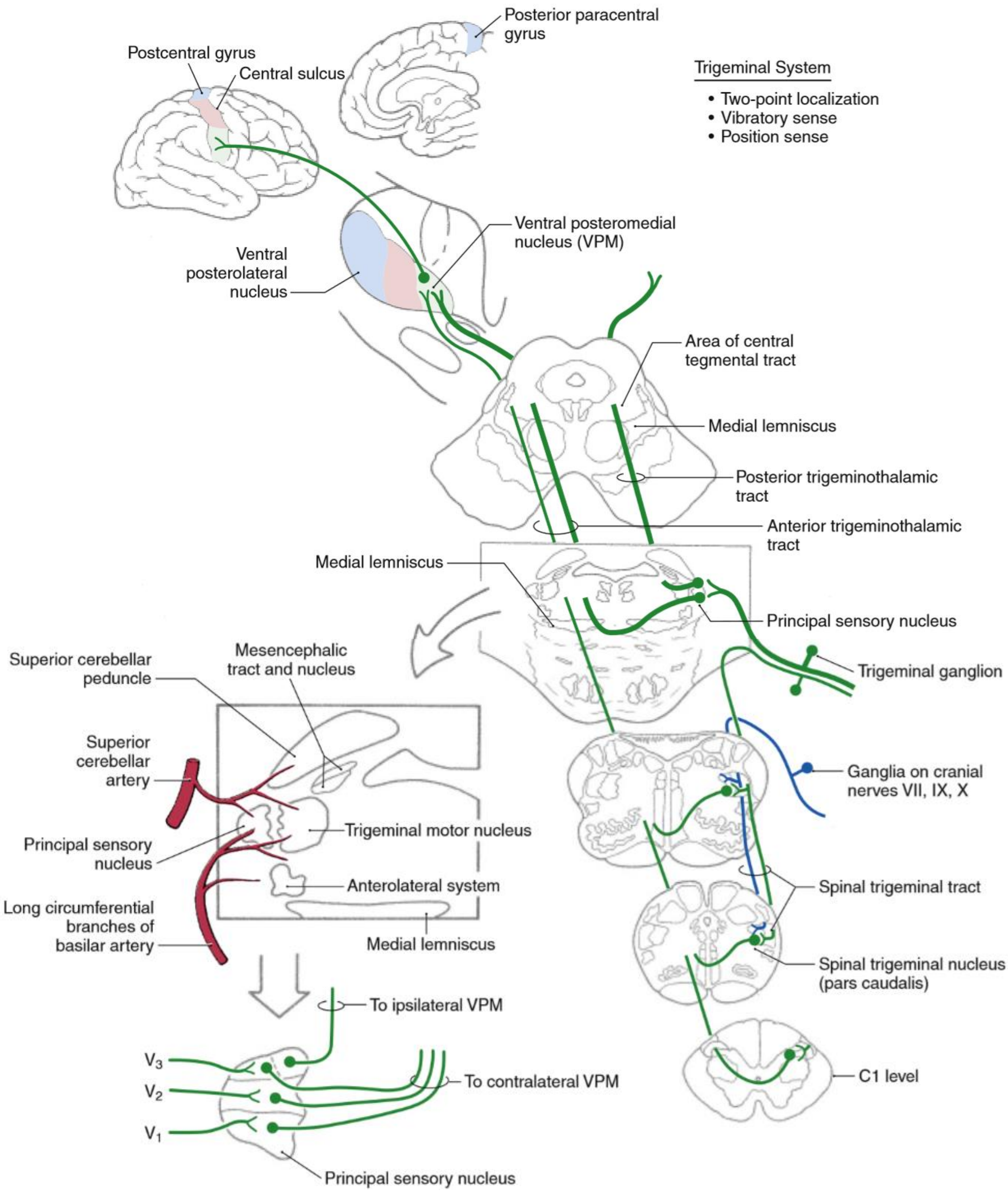

Principal sensory nucleus
Mesencephalic nucleus
Facial colliculus
Spinal trigeminal nucleus:
Pars oralis
Pars interpolaris
Pars caudalis
Obex
Level of the pyramidal decussation
Vestibular area
Sulcus limitans
Hypoglossal trigone
Vagal trigone
Gracile tubercle

- Nuclei: 3 sensory (form a column) and 1 motor. 2nd order neurons.
  The sensory nuclei are located one over the other. From inferior:
    - Spinal trigeminal nucleus – GSA
      Location: lateral medulla and pons, most inferior trigeminal nucleus.
      Function: pain and thermal sensations from the face and head.
      Input: cranial nerves 5, 7, 9, 10.
      Structure: has 3 parts:
      a. Caudal – from C3 level in the spinal cord to obex.
      b. Interpolar – from obex to hypoglossal nucleus.
      c. Oral – to principal nucleus above it.
    - principal sensory nucleus – GSA
      Location: lateral pons, superior to spinal trigeminal nucleus.
      Function: Sensation of discriminative touch from face and oral cavity.
      ** information from the principal and spinal nuclei go to thalamus (VPM) through the anterior and posterior trigeminothalamic tracts, and ends on the somatosensory cortex.
    - Mesencephalic nucleus – GSA
      Location: lateral midbrain, lateral to the periaqueductal gray. Most superior trigeminal nucleus.
      Function: proprioceptive information, from masticatory muscles, extraocular muscles, and periodontal ligament receptors.

- Information from the nuclei is transmitted to the VPM –
- Oral cavity and face > principal sensory trigeminal nucleus > VPM in Thalamus >
    - Anterior trigeminothalamic tract (trigeminal lemniscus): fibers of spinal trigeminal nucleus + ventrolateral part of principal nucleus. They decussate to contralateral VPM. The trigeminal lemniscus passes adjacent to the medial lemniscus.
    - Posterior trigeminothalamic tract: dorsomedial part of principal nucleus. Receives information mainly from the oral cavity and projects to the ipsilateral VPM. Ascends in the tegmentum of Pons, lateral to periaqueductal gray.
- Proprioception from mastication muscles: from the trigeminal mesencephalic nucleus fibers pass adjacent to the periaqueductal gray and. they also give input to the other trigeminal nuclei, including fibers to the motor trigeminal nucleus that creates the jaw jerk reflex and regulates force of mastication.
  jaw jerk reflex – used to check the trigeminal nerve. The mandible is pushed downward to open the mouth, and the masseter muscle should resist.
- Proprioception from the temporomandibular joint and extraocular muscles: end in the principle and spinal trigeminal nuclei.
- The spinal trigeminal nucleus forms the trigeminal tubercle (tuberculum Cinereum) in the closed part of the medulla. Page 251.

Third order neurons – found in the VPM nucleus of Thalamus

- Information is represented somatotopically –oral cavity is represented on the medial side and the external face on the lateral side.
- The fibers of VPM project through the posterior limb of the internal capsule, to the primary somatosensory cortex on the postcentral gyrus (Brodmann area 4).

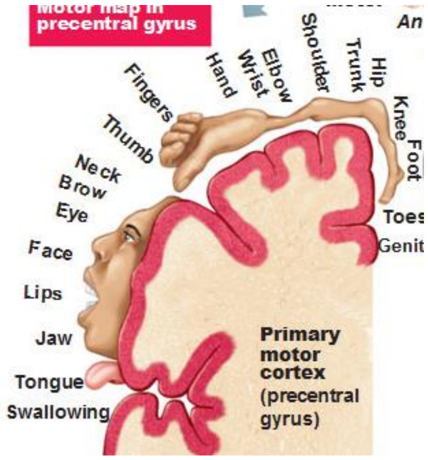

Posterior paracentral gyrus
Postcentral gyrus
Central sulcus
Trigeminal System
• Two-point localization
• Vibratory sense
• Position sense
Ventral posteromedial nucleus (VPM)
Ventral posterolateral nucleus
Area of central tegmental tract
Medial lemniscus
Posterior trigeminothalamic tract
Anterior trigeminothalamic tract
Medial lemniscus
Principal sensory nucleus
Trigeminal ganglion
Superior cerebellar peduncle
Mesencephalic tract and nucleus
Superior cerebellar artery
Trigeminal motor nucleus
Principal sensory nucleus
Anterolateral system
Long circumferential branches of basilar artery
Medial lemniscus
Ganglia on cranial nerves VII, IX, X
Spinal trigeminal tract
Spinal trigeminal nucleus (pars caudalis)
C1 level
To ipsilateral VPM
V_3
V_2
V_1
To contralateral VPM
Principal sensory nucleus

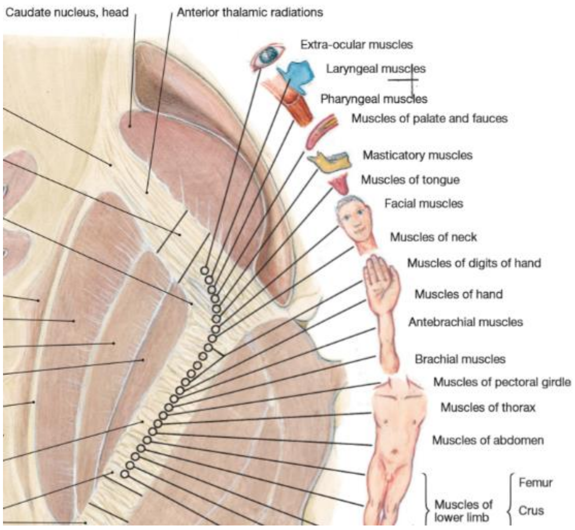
Topic 5 – Demonstration of the structures related to the somatomotor innervation of the head and neck (excluding the cervical plexus).

Hain's 346.

- The somatomotor innervation of the head and neck is delivered by the cranial nerves and the cervical spinal nerves. Their nuclei and nerves are described in previous topics.
  - Cranial nerves 3, 4 and 6 control the extraocular muscles.
  - Cranial nerve 5 controls the masticatory muscles.
  - Cranial nerve 7 controls facial expression muscles
  - Cranial nerve 9 controls pharyngeal muscles.
  - Cranial nerve 10 controls the pharyngeal and laryngeal muscles. Nucleus ambiguus gives the motor control for C.N. 9 and 10.
  - Cranial nerve 11 controls the neck muscles.
  - Cranial nerve 12 controls tongue muscles.

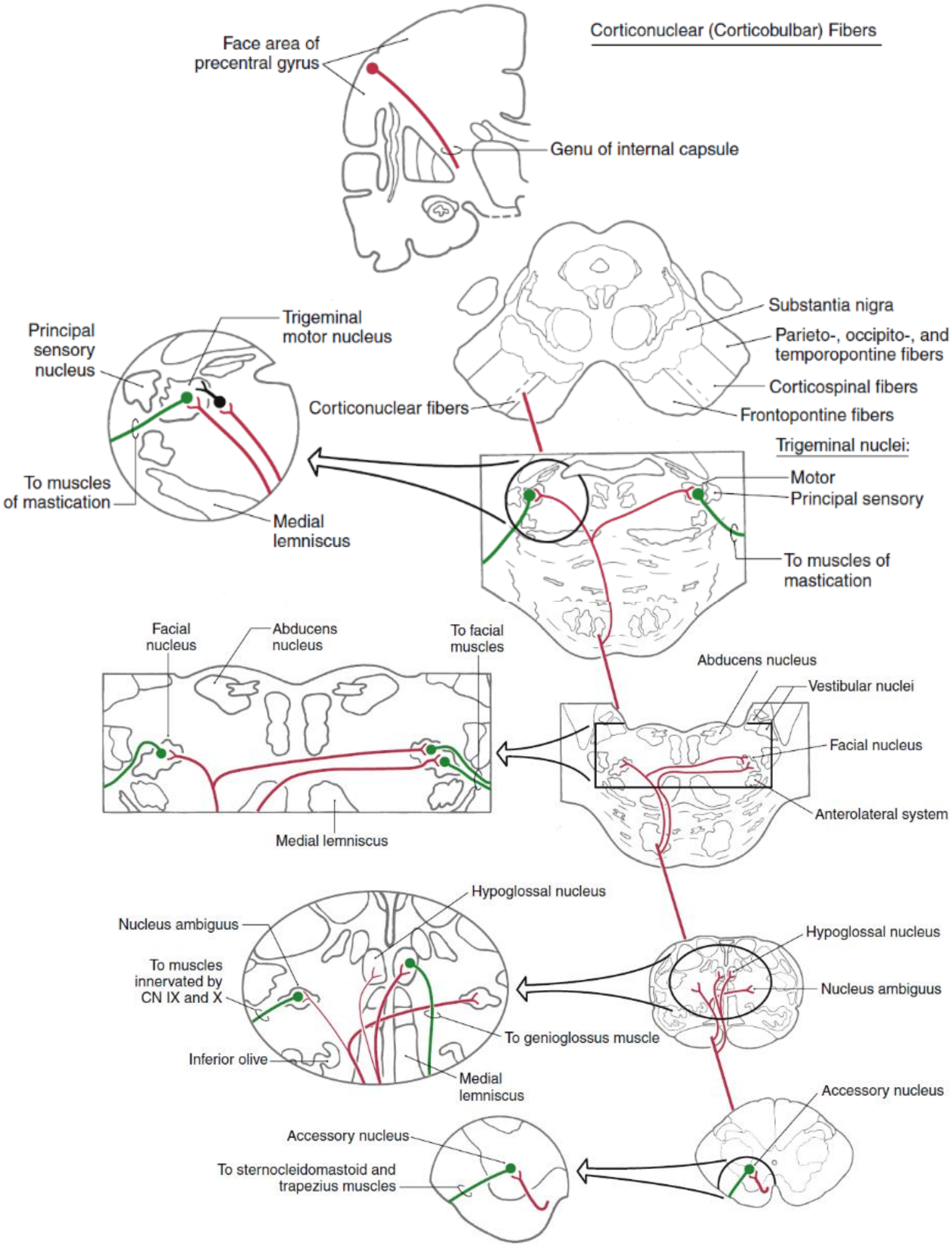
- The pathway:
  1. The first order neuron if located in the precentral gyrus – the primary motor cortex. Same as the somatomotor innervation of the body. The face is represented on the lower part of the gyrus.
     The area that controls the eye movement is different. It is located on the frontal and parietal motor eye field. It sends fibers to the nuclei through the reticular formation.
  2. From there, fibers continue to the Internal capsule through the Corona Radiata.
  3. In the Internal capsule the fibers pass through the Genu. These fibers are called Corticonuclear (and also corticobulbar) tract – from the cortex to motor nuclei of cranial nerves.
  4. At the Crus Cerebri the fibers pass adjacent to the corticospinal fibers.


Motor map in precentral gyrus
Hand
Wrist
Elbow
Shoulder
Trunk
Hip
An
Knee
Foot
Toes
Genit
Fingers
Thumb
Neck
Brow
Eye
Face
Lips
Jaw
Tongue
Swallowing
Primary motor cortex (precentral gyrus)


Caudate nucleus, head
Anterior thalamic radiations
Extra-ocular muscles
Laryngeal muscles
Pharyngeal muscles
Muscles of palate and fauces
Masticatory muscles
Muscles of tongue
Facial muscles
Muscles of neck
Muscles of digits of hand
Muscles of hand
Antebrachial muscles
Brachial muscles
Muscles of pectoral girdle
Muscles of thorax
Muscles of abdomen
Muscles of lower limb
Femur
Crus

  5. From there, the fibers continue to the brain stem and are distributed to the different nuclei. The nuclei, the nerves and the activity of the cranial nerves are detailed in the previous topics. Fibers innervating cranial nerve 11 continue to the cervical part of the spinal cord.

- Fibers from each hemisphere are sent to the nuclei of both sides in equal amount, so damage on one side would not cause paralysis. The lower half of the face and the muscles of soft palate are exception, as they are controlled mainly by the contralateral hemisphere.


Corticonuclear (Corticobulbar) Fibers
Face area of precentral gyrus
Genu of internal capsule
Substantia nigra
Parieto-, occipito-, and temporopontine fibers
Corticospinal fibers
Frontopontine fibers
Corticonuclear fibers
Principal sensory nucleus
Trigeminal motor nucleus
To muscles of mastication
Medial lemniscus
Trigeminal nuclei:
Motor
Principal sensory
To muscles of mastication
Facial nucleus
Abducens nucleus
To facial muscles
Medial lemniscus
Abducens nucleus
Vestibular nuclei
Facial nucleus
Anterolateral system
Hypoglossal nucleus
Nucleus ambiguus
To muscles innervated by CN IX and X
Inferior olive
To genioglossus muscle
Medial lemniscus
Hypoglossal nucleus
Nucleus ambiguus
Accessory nucleus
Accessory nucleus
To sternocleidomastoid and trapezius muscles

Topic 6 – Demonstration of the Pain Sensation

Hain's 241

- Transmit information of pain (nociception), temperature and Non-discriminative (crud, גס) touch.
- The information passes through the **Anterolateral system**.
- Function: Producing pain (nociception) and thermal sensation to protect the body by avoiding the danger and thus preventing damage.
- The information comes from Mechanoreceptors, Chemoreceptors and Thermoreceptors.
- The fibers have Small diameter, thin myelin and slow conduction speed. They make poor localization of the signal.
- Anterior trigeminothalamic pathway: similar information from face, head and oral cavity.
- ****Very important**: in the past the anterolateral system was divided to anterior and lateral Spinothalamic tracts, with the following characteristics:
  - Lateral Spinothalamic tract – carries pain and thermal information, pass in the lateral funiculus.
  - Anterior Spinothalamic tract – carries non-discriminative information, pass in the anterior funiculus.
- Nowadays it is known, and mentioned in the lectures of the department, that there is no such distribution, and all modalities (pain, thermal, touch) pass together, through direct and indirect pathways to the cortex.
  The main indirect pathways (Paleospinothalamic, considered older) are:
  - Spinoreticular – to the reticular formation. The main indirect pathway.
  - Spinothalamic – from spine to ventral posterolateral (VPL), ventral posterior inferior (VPI) and posterior group.
  - Spinotectal – to tectum.
  - Spinomesencephalic – to periaqueductal gray.
- The direct Pathway (Neospinothalamic, considered newer): receptor > spinal nerve > Dorsal Root Ganglion > Anterolateral spinal cord > brain stem > Posterior nuclei of Thalamus > Posterior limb of Internal Capsule > somatosensory cortex.

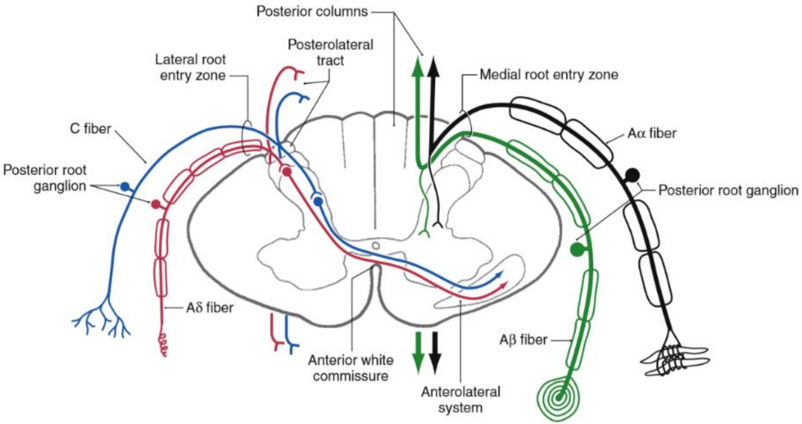
1. Receptor.

2. Dorsal Root Ganglion:

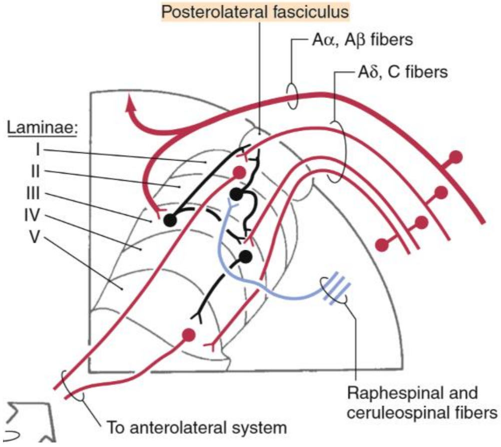
- Location of the cell body of the 1st order neuron. It sends peripheral process to the receptor and central process to the gray matter of spinal cord, in laminae 1-5. It enters through the lateral division of the posterior root (the DCMLS enters through the medial part of the root, topic 22).

3. Entering the White Matter and terminating in the gray matter of Spinal Cord:

Direct pathway:	Indirect pathway:
• Mostly Aδ fibers (thin myelin). Modalities: crud touch, innocuous (בלתי מזיק) thermal and nociception info. • Fibers enter through the posterolateral fasciculus (Lissauer tract), and give ascending and descending branches to adjacent spinal levels: o Descending: end in interneurons of layers above and below > make spinal reflexes (simple reflex, doesn't pass in the brain). o Ascending: end in 2nd motor neuron in lamina 1 of post. horn. Their fibers continue into the Thalamus.	• Mostly C fibers (non-myelinated). Modalities: noxious (מזיק) and innocuous mechanical and thermal info. • Fibers enter through the posterolateral fasciculus (Lissauer tract), and give ascending and descending branches that go to adjacent spinal levels, to laminae 2 and 3. There they synapse with interneurons. • The interneurons communicate with cells in laminae 5-8.


Posterior columns
Posterolateral tract
Lateral root entry zone
Medial root entry zone
C fiber
Aα fiber
Posterior root ganglion
Posterior root ganglion
Aδ fiber
Aβ fiber
Anterior white commissure
Anterolateral system

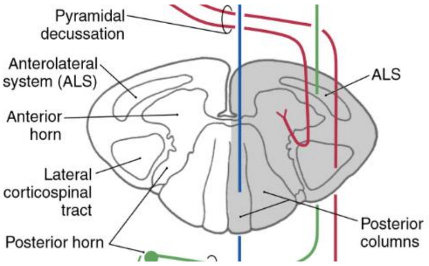
Dorsal column fibers: A-alpha, A-beta fibers. Enter more medially.

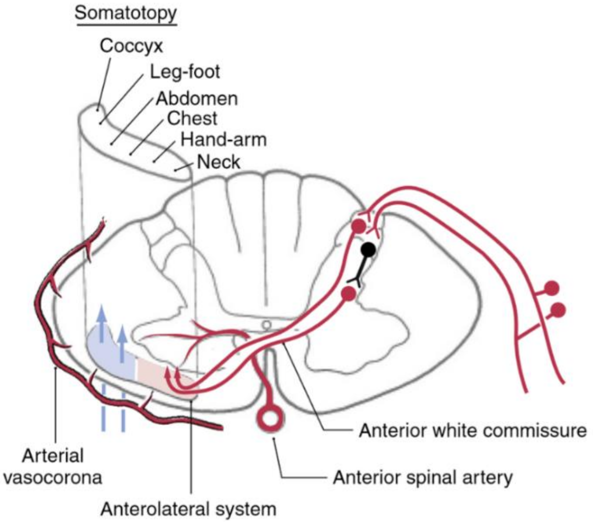

Posterolateral fasciculus
Aα, Aβ fibers
Aδ, C fibers
Laminae:
I
II
III
IV
V
Raphespinal and ceruleospinal fibers
To anterolateral system

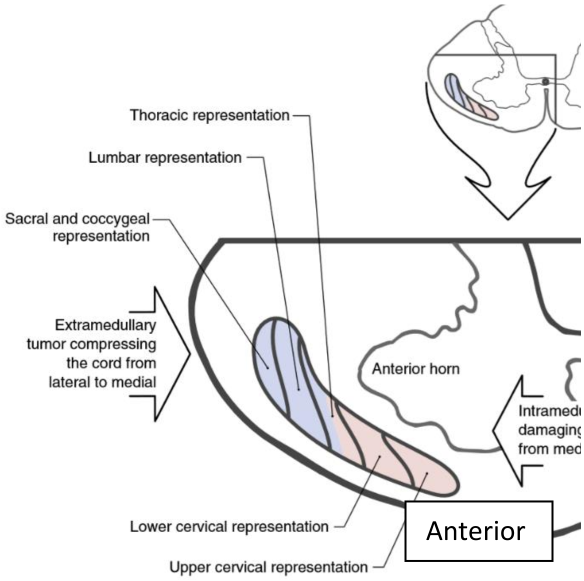
4. exiting to the White Matter and ascending:

Direct pathway:	Indirect pathway:
- Most ascending fibers cross to the contralateral ALS through the Anterior White Commissure. Few fibers remain ipsilateral.	- Axons from the gray matter cross through the Anterior White Commissure and join the contralateral ALS.

- Then fibers ascend in the anterolateral region of white matter (you can remember it has opposite location to the dorsal column):
  - Information from upper body parts ends anterior and medially.
  - Information from lower body parts ends posterior and laterally.
- Blood supply to ALS: Anterior Spinal artery and Arterial Vasocorona (arterial network made by spinal medullary arteries).


Pyramidal decussation
Anterolateral system (ALS)
Anterior horn
Lateral corticospinal tract
Posterior horn
ALS
Posterior columns


Somatotopy
Coccyx
Leg-foot
Abdomen
Chest
Hand-arm
Neck
Arterial vasocorona
Anterolateral system
Anterior white commissure
Anterior spinal artery


Thoracic representation
Lumbar representation
Sacral and coccygeal representation
Extramedullary tumor compressing the cord from lateral to medial
Anterior horn
Intramedu
damaging
from med
Lower cervical representation
Upper cervical representation
Anterior

5. Medulla:

- ALS is found anterolaterally.
- Pass lateral to the inferior olive, and anterior to spinal trigeminal nucleus.
- The tract decrease in size as the indirect pathways give fibers to the reticular formation (spinoreticular) and other nuclei.
- Spinal lemniscus – fibers conveying pain sensation from spinal cord (spinothalamic) and fibers from brain stem (indirect pathways) join and ascend to the Thalamus.

6. Pons:

- ALS fibers pass in the lateral region. Medial lemniscus come close to it.
- Some indirect fibers leave to the reticular formation (spinoreticular).

7. Midbrain:

- ALS fibers pass in the lateral part of tegmentum. Medial lemniscus stays close to ALS.
- Some indirect fibers leave to the superior colliculus (Spinotectal) and Periaqueductal gray matter (Spinomesencephalic).

8. 3rd order neuron:

Direct pathway:	Indirect pathway:
• Fibers end in the thalamus, mainly in ventral posterolateral (VPL), ventral posteroinferior (VPI), and posterior group. • From here fibers project to the somatosensory cortex. • On the VPL, the upper body is showed laterally and lower body showed medially.	• end in the brain stem: Spinoreticular (reticular formation), Spinotectal (Superior Colliculi + Pretectal nuclei), Spinomesencephalic (periaqueductal gray mater + midbrain Reticular Formation) and others pathways. • These structures then send fibers to the Thalamus (Intralaminar and posterior nuclei) and then to many cortical parts.

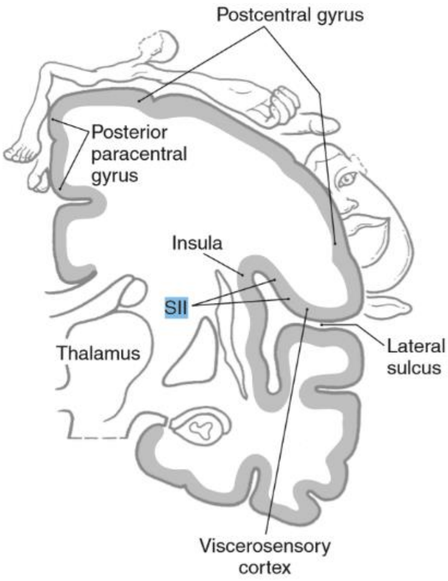
**pain fibers from face get to VPM through the spinal trigeminal nucleus.

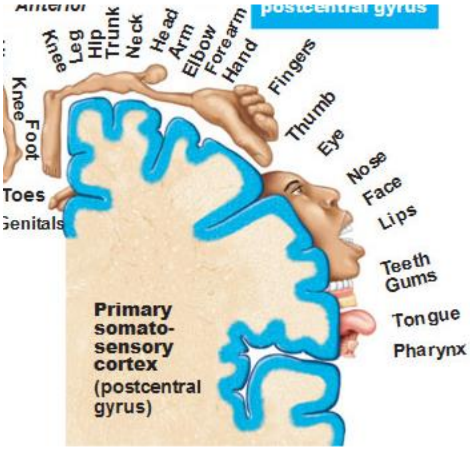
9. Internal Capsule:

- Thalamocortical tract passes in the Posterior limb of the Internal Capsule.

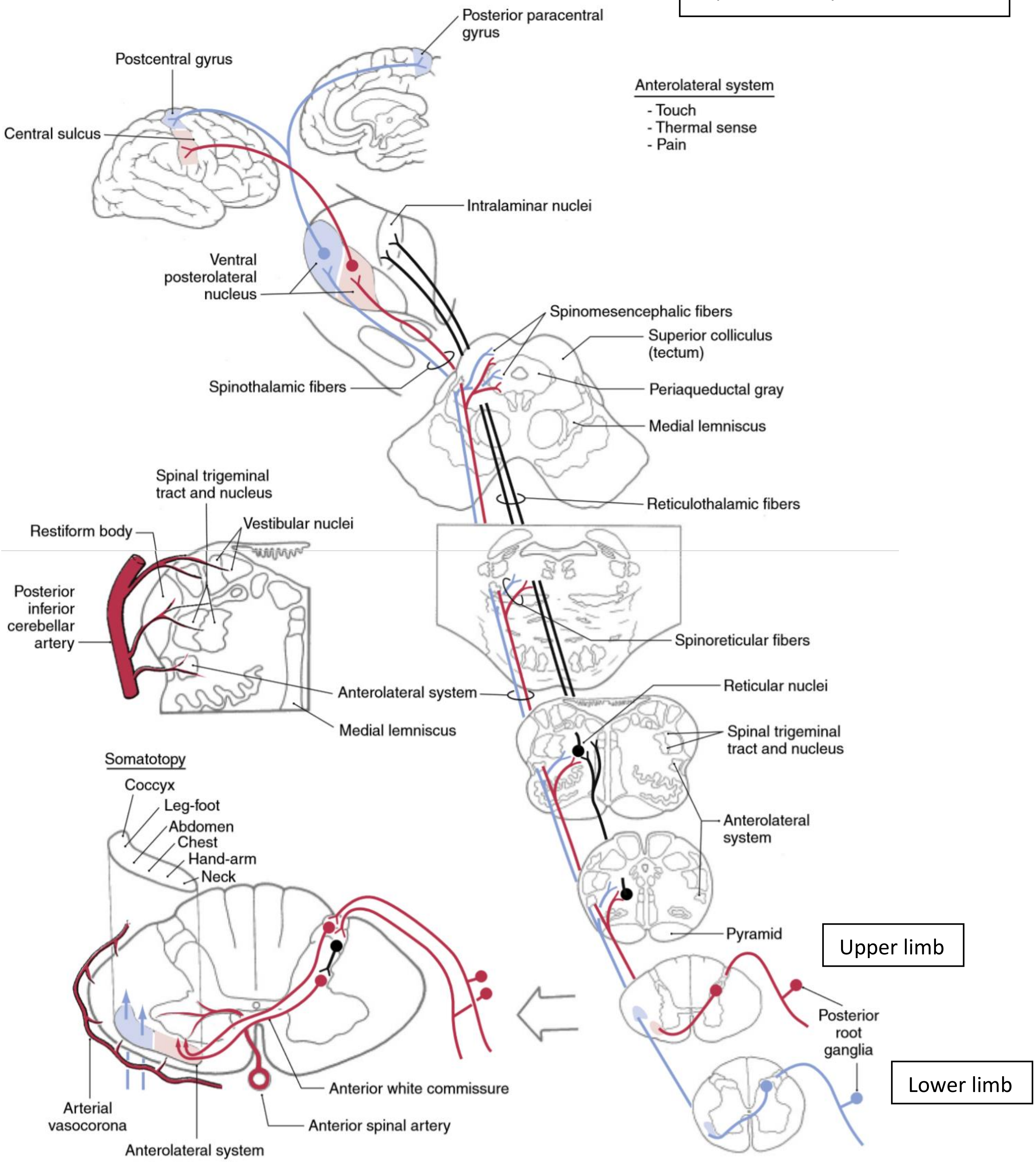
10. Cortex:

- Fibers of the direct pathway continue from the Thalamus to the Cortex:
  - Fibers from VPL end mainly in the primary somatosensory cortex, Brodmann area 3, 2, 1. on it, the fibers are somatotopically arranged.
    - ✈ The lower limb is represented on the posterior paracentral gyrus.
    - ✈ The rest is represented on the postcentral gyrus.
  - Some fibers end in the secondary somatosensory cortex (SII, inside the lateral sulcus) and insular cortex.
- Fibers of the indirect pathways continue from Intralaminar nucleus of thalamus to the limbic system (Hippocampus, Cingulate gyrus, Amygdala) to inform it about the pain.
  from the posterior nuclei – information continues to SII and insula.
- Blood supply – Anterior and Middle cerebral arteries.


Postcentral gyrus
Posterior paracentral gyrus
Insula
SII
Thalamus
Lateral sulcus
Viscerosensory cortex


Knee
Leg
Hip
Trunk
Neck
Head
Arm
Elbow
Forearm
Hand
Fingers
Thumb
Eye
Nose
Face
Lips
Teeth
Gums
Tongue
Pharynx
Knee
Foot
Toes
Primary somato-sensory cortex (postcentral gyrus)

The indirect fibers are represented by the black lines.


Posterior paracentral gyrus
Postcentral gyrus
Central sulcus
Anterolateral system
- Touch
- Thermal sense
- Pain
Intralaminar nuclei
Ventral posterolateral nucleus
Spinomesencephalic fibers
Superior colliculus (tectum)
Spinothalamic fibers
Periaqueductal gray
Medial lemniscus
Spinal trigeminal tract and nucleus
Reticulothalamic fibers
Restiform body
Vestibular nuclei
Posterior inferior cerebellar artery
Spinoreticular fibers
Anterolateral system
Reticular nuclei
Medial lemniscus
Spinal trigeminal tract and nucleus
Somatotopy
Coccyx
Leg-foot
Abdomen
Chest
Hand-arm
Neck
Anterolateral system
Pyramid
Upper limb
Posterior root ganglia
Lower limb
Anterior white commissure
Arterial vasocorona
Anterior spinal artery
Anterolateral system

Topic 7 – Demonstration of the structures related to the motor coordination of eye movement

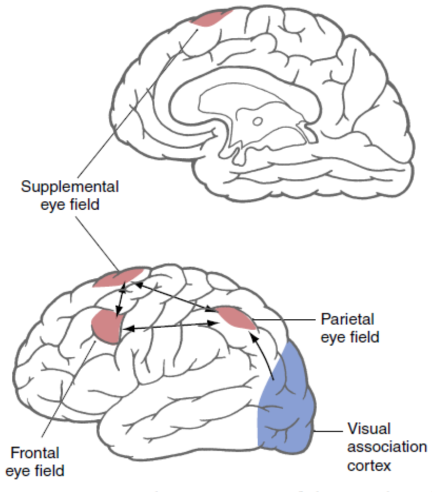
Hain's 389

- The eye movement is controlled by 6 muscles. These muscles must cooperate excellently to form smooth and delicate movement of the eye.
- In addition, the movement of the eye is effected by few inputs – the voluntary control from the cortex, and sensory input from the vestibular, auditory and visual systems.
- The main movement of the eye is saccade movement – rapid movement of the eye from side to side, stopping on different points called fixation points.

The structures involved:

- The Cranial nerves 3, 4 and 6 and their nuclei. They control the extraocular muscles. Details about these nuclei is found in the appropriate topics.
  - They receive inputs from the cortical areas, superior colliculi, gaze centers in the brain stem and the vestibular nucleus.

- Frontal eye field (FEF)– the area in the cortex in charge of voluntary control of the eye movement.
  - Output: projects to C.N. 3, 4, 6 that control the extraocular muscles. Fibers pass through vertical and horizontal gaze centers and the Superior colliculi.
  - Input: other cortical area.
  - Function: Controls voluntary saccadic eye movement.
  - Location: Precentral sulcus and Middle Frontal gyrus, and assigned as Brodmann area 6 and partly 8.
  - On the frontal lobe you can also find the supplemental eye field, located on the superior frontal gyrus. The cortical area involved in controlong the eye movement are called "cortical eye fields". They communicate with each other. The main one is the frontal eye field.
  - Accessory visual cortex, on the occipital lobe, also supplies information.



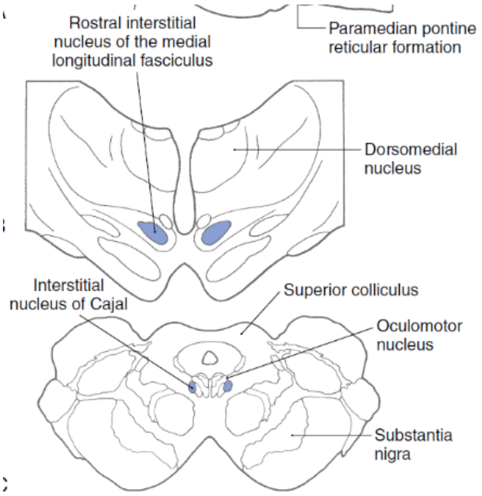
- Parietal eye field (PEF) –
  - Location: around the Intraparietal sulcus, Brodmann area 7.
  - Function: involved in the controlling of the eye movement.
  - Input: other cortical areas.
  - Output: projects to C.N. 3, 4, 6 that control the extraocular muscles. Fibers pass through vertical and horizontal gaze centers and the Superior colliculi.

- Superior colliculus –
  - Location: Tectal part of midbrain.
  - Function: Controls reflexive saccadic eye movements, together with the cortical eye fields.
  - Input: Cortical areas controlling eye movement.
  - Output: Nuclei of Cranial nerves 3,4 and 6 through the vertical and horizontal gaze centers.

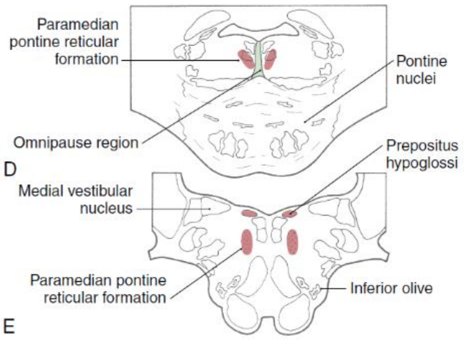
- Vertical gaze center – also called rostral interstitial nucleus of the medial longitudinal fasciculus – riMLF).
    - Input: Frontal eye field and the Superior colliculus.
    - Output: nuclei of cranial nerves 3, 4 and 6 on the 2 sides.
    - Function: control the phasic signal of saccade activity.
    - They cooperate with interstitial nucleus of Cajal.
    - The medial longitudinal fasciculus is located – pass through the center of the brain stem, through pons and brain stem.

- Horizontal gaze center – also called paramedian pontine reticular formation (PPRF).
    - Input: Frontal eye field and the Superior colliculus.
    - Output:
    - Function: initiate horizontal saccade activity. When looking to one side, it activates the abducent nucleus of one side and inhibit the opposite one, with the help of excitatory and inhibitory neurons adjacent to the abducent nucleus.
    - The pontine reticular formation is located – pass in the center of the brain stem, through the medulla and pons.

- Flocculus –
    - Function: analyze information of smooth pursuit of the eyes and passes it to the vestibular nuclei.
    - Location: the lower lobe of the cerebellum, on the hemisphere.
    - Input: cortical eye fields.
    - Output: vestibular nuclei.


Rostral interstitial nucleus of the medial longitudinal fasciculus
Paramedian pontine reticular formation
Dorsomedial nucleus
Interstitial nucleus of Cajal
Superior colliculus
Oculomotor nucleus
Substantia nigra

- The vestibular nuclei –
    - Input: flocculus of the cerebellum.
    - Output: medial longitudinal fasciculus.
    - Function: gives information to nuclei of C.N. 3, 4 and 6 for producing smooth eye movement.
    - Location: lateral part of rhomboid fossa, on medulla and pons.


Paramedian pontine reticular formation
Pontine nuclei
Omnipause region
D
Prepositus hypoglossi
Medial vestibular nucleus
Paramedian pontine reticular formation
Inferior olive
E

- Basal nuclei –
    - Including the caudate and the substantia nigra.
    - Involved in the initiation of motor movement.
    - The substantia nigra gives input to the superior colliculus. It effects the saccade movement.

Topic 8 – Demonstration of the Extraocular muscles on the eye specimen or eye model. The origin and intracranial course of the Nerves supplying the extraocular muscles

Hain's 389. Moore 898.

- The 6 extrinsic muscles move the eye. They are controlled by 3 cranial nerves.
- The eye moves in 3 axes: vertical, transverse and anteroposterior. The muscle work in pairs, and antagonise each other – each muscle moves the eye to the opposite direction:
    - Transverse axis – up-down movement, by superior and inferior recti muscles.
    - Vertical axis – medial-lateral movement, by medial and lateral recti muscles.
    - Anteroposterior – rotational movement, by inferior and superior oblique muscles.
- In most movements of the eye, many muscles work together.
- These are striated muscles that contract very fast, and can maintain tension for long time.
- The muscles have very small motor unit – one nerve fiber innervate only few muscle fibers – which make the muscles very accurate.
- C.N. 5 carry proprioceptive information from these muscles, into the mesencephalic trigeminal nucleus. The vision itself also gives information about the position of the eye.
- Problem with correlation of eye movement can cause double vision.
- This formula can help remember the innervation of the muscles - (SO4 LR6) 3 – superior oblique C.N. 4, lateral rectus C.N. 6, all others C.N. 3.
- The Check Ligaments and Retrobulbar Fat resist the pull of the eyeball posteriorly.

Rectus muscles:

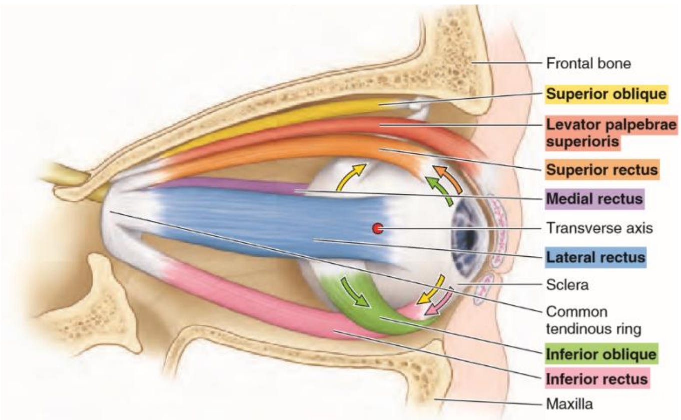
- All originate from the Common Tendinous Ring, and insert on the anterior part of sclera.
- Superior rectus – elevates the eye. Innervated by C.N. 3.
- Inferior rectus – depresses the eye. Innervated by C.N. 3.
- Medial rectus – adduct the eye. Innervated by C.N. 3.
- Lateral rectus – abduct the eye. Innervated by C.N. 6. (abducent – abduct the eye, lateral).
- To test the superior and inferior rectus alone, one should first move the eye lateral, because in that position, only these muscle have an effect, so only the up-down axis is active.
- An extension from the medial and lateral rectus forms the medial and lateral Check Ligaments. They attach the lacrimal and zygomatic bone and limit the abduction and adduction.

Oblique muscles:

- Superior oblique –
    - Originate at the back of the orbit, from the sphenoid bone. Then it passes through a Trochlea on the medial side of the eye, that changes its direction.
    - Its main function is medial rotation. Secondary functions are depression and abduction.
    - Innervated by C.N. 4 (Trochlear n., as the muscle it innervates passes through a trochlea).
- Inferior oblique –
    - the only muscle that originate from the anterior part of orbit, lateral to the lacrimal fossa, and inserts on the inferior surface to the eye.
    - Its main function is lateral rotation. Secondary functions are elevation and abduction.
    - Innervated by C.N.3.

- To test the superior and inferior oblique alone, one should first move the eye medial, because in that position, only these muscle affect the up-down axis.

**Notice – the Levator Palpebrae Superioris passes partly above the superior rectus.


Frontal bone
Superior oblique
Levator palpebrae superioris
Superior rectus
Medial rectus
Transverse axis
Lateral rectus
Sclera
Common tendinous ring
Inferior oblique
Inferior rectus
Maxilla

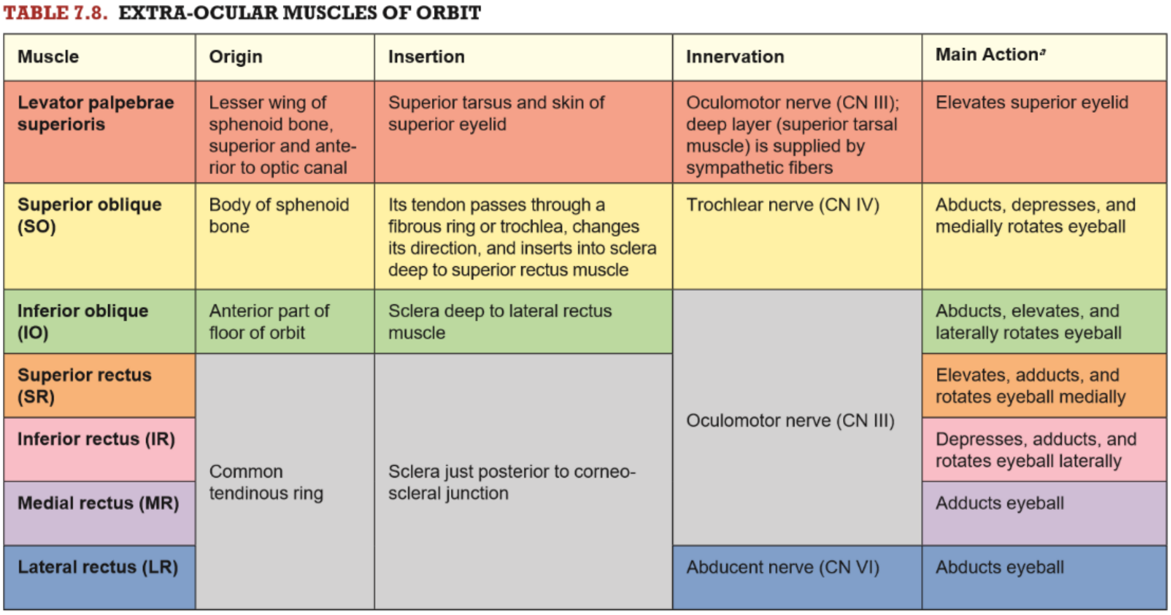


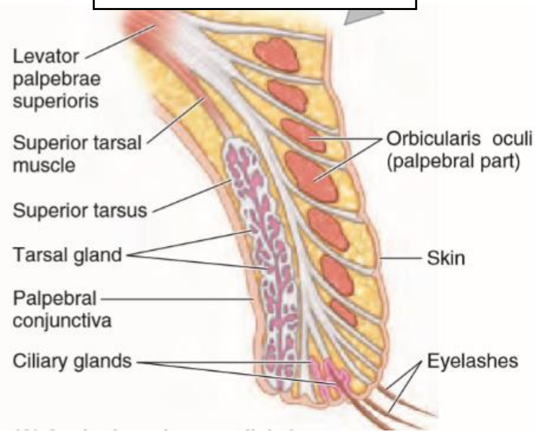
TABLE 7.8. EXTRA-OCULAR MUSCLES OF ORBIT

Muscle	Origin	Insertion	Innervation	Main Action^a
Levator palpebrae superioris	Lesser wing of sphenoid bone, superior and anterior to optic canal	Superior tarsus and skin of superior eyelid	Oculomotor nerve (CN III); deep layer (superior tarsal muscle) is supplied by sympathetic fibers	Elevates superior eyelid
Superior oblique (SO)	Body of sphenoid bone	Its tendon passes through a fibrous ring or trochlea, changes its direction, and inserts into sclera deep to superior rectus muscle	Trochlear nerve (CN IV)	Abducts, depresses, and medially rotates eyeball
Inferior oblique (IO)	Anterior part of floor of orbit	Sclera deep to lateral rectus muscle	Oculomotor nerve (CN III)	Abducts, elevates, and laterally rotates eyeball
Superior rectus (SR)	Common tendinous ring	Sclera just posterior to corneo-scleral junction		Elevates, adducts, and rotates eyeball medially
Inferior rectus (IR)				Depresses, adducts, and rotates eyeball laterally
Medial rectus (MR)				Adducts eyeball
Lateral rectus (LR)			Abducent nerve (CN VI)	Abducts eyeball

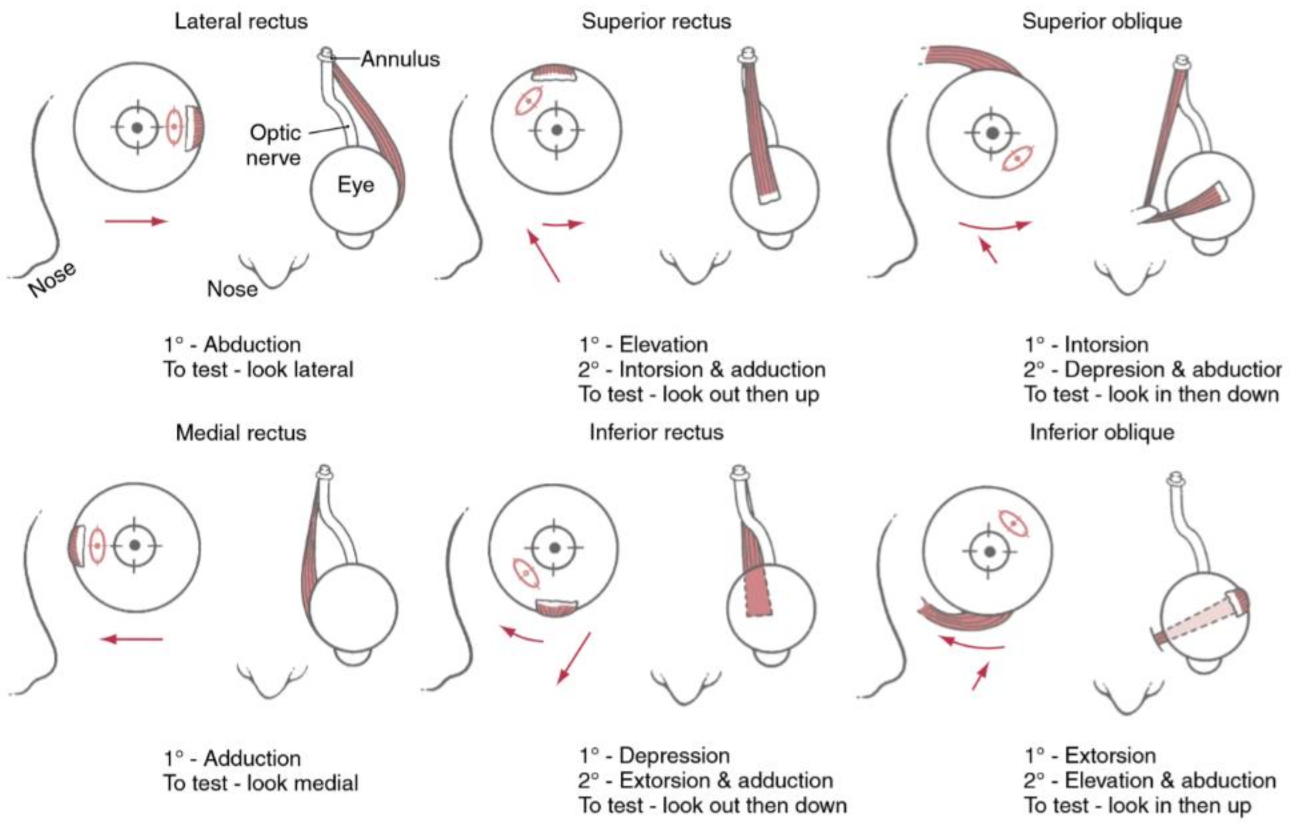
Eyelid:

- Covers the eye and protects it.
- Has inner layer of Conjunctiva – Palpebral Conjunctiva. It spreads tear on the eye and spared the tear when the eye closes.
- Participates in the corneal reflex – when something touches the cornea, the eye lid closes.
- Has few muscles:
  - Orbicularis oculi – fascial expression muscle. Closes the eye. Innervated by C.N. 7.
  - Levator Palpebrae Superioris – forms a layer of aponeurosis in the eye lid. It lifts the eyelid, and oppose gravity to keep the eyelid open. Innervated by C.N. 3.
  - Superior Tarsal muscle – inner part of the Levator Palpebrae Superioris.
    Function: keeps the eye open in case of fight or flight situations, and in normal condition.
    Innervation: sympathetic system. fibers from superior cervical ganglion, enter on the internal

There is also **inferior tarsal muscle** on the inferior eyelid

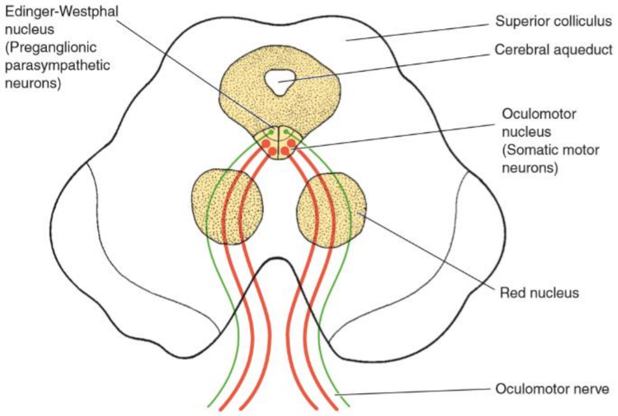

Levator palpebrae superioris
Superior tarsal muscle
Superior tarsus
Tarsal gland
Palpebral conjunctiva
Ciliary glands
Orbicularis oculi (palpebral part)
Skin
Eyelashes

carotid plexus, pass next to C.N.6 and reach the palpebral next to fibers of C.N. 3.
SNS fibers that innervate Dilator Pupillae muscle travel next to C.N. 5 as long ciliary nerve.


Lateral rectus
Annulus
Optic nerve
Eye
Nose
Nose
1° - Abduction
To test - look lateral
Superior rectus
1° - Elevation
2° - Intorsion & adduction
To test - look out then up
Superior oblique
1° - Intorsion
2° - Depresion & abductior
To test - look in then down
Medial rectus
1° - Adduction
To test - look medial
Inferior rectus
1° - Depression
2° - Extorsion & adduction
To test - look out then down
Inferior oblique
1° - Extorsion
2° - Elevation & abduction
To test - look in then up

The red target is the direction to which the pupil will move when the muscle pulls the eye alone.

Don't forget that normally few muscles work together.

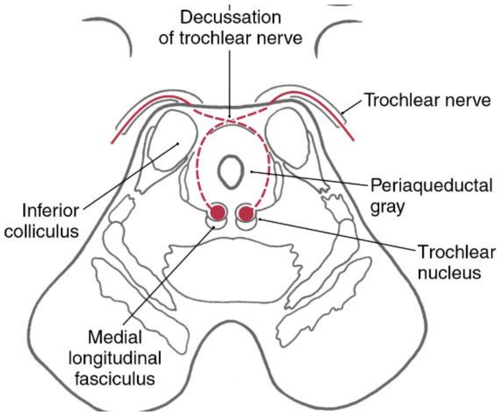

Edinger-Westphal nucleus (Preganglionic parasympathetic neurons)
Superior colliculus
Cerebral aqueduct
Oculomotor nucleus (Somatic motor neurons)
Red nucleus
Oculomotor nerve

Cranial nerves: all communicate through the Medial Longitudinal Fasciculus to make smooth and coordinated eye movement of the muscles of the eye.

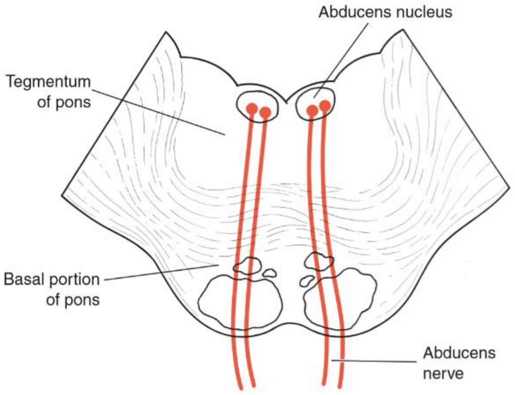
1. C.N. 3 – Oculomotor nerve: SM.
   - Function:
     Innervates extra-ocular muscles – superior, Medial and Inferior rectus, inferior oblique and the Levator Palpebrae Superioris.
   - Nuclei:
     oculomotor nucleus – SM.
     Location: periaqueductal gray matter of midbrain, anterior to the aqueduct, at the level of superior colliculus.
     input: Corticonuclear, Tectobulbar – from superior colliculus.
     *Anterior to it passes the Medial Longitudinal Fasciculus, that forms communication of C.N. 3,4,6.

- Nerve:
  Oculomotor nerve: cross the red nucleus, exit the midbrain through the interpeduncular fossa, between the posterior cerebral and superior cerebellar arteries, pass through the cavernous sinus and then pass through the superior orbital fissure. It terminates in the orbit and supply the muscles.

- Edinger-Westphal nucleus – VM. Also called 'accessory parasympathetic nucleus'.
  Location: posterior to Oculomotor nucleus. Doesn't affect extraocular muscles but is related to the eye activity and to the Oculomotor nucleus. Has PNS function.
  Input: from cortex. Output: controls the Ciliary muscle and Sphincter Pupillae.
  Edinger-westphal nerve: travels with the ipsilateral oculomotor nerve, ends in the Ciliary ganglion. Postganglionic fibers travel through the Short Ciliary nerve, that supply Sphincter Pupillae muscle (makes the pupil smaller) and Ciliary muscle (controls the lens thickness).



2. C.N. 4 – Trochlear nerve: SM.
   - Function: innervates the **contralateral** superior oblique muscle.
     **remember – trochlear nerve supply the muscle that passes in a trochlea.
   - Nucleus: anterior to central gray matter, inferior colliculus level.
     Input: 1) hemispheres, through Corticonuclear fibers.
     2) Visual cortex – Tectobulbar fibers.
     3) connection with C.N. 3,6 – Medial Longitudinal Fasciculus.
   - Nerve: it is the only C.N. that exit the midbrain posteriorly.
     only nerve which has crossed fibers – from the nucleus the fibers surround the periaqueductal gray matter, decussate before they exit the midbrain next to the inferior colliculus. Then it turns anteriorly to pass through the Cavernous Sinus. exit to the orbit through the Superior Orbital Fissure, and end in the muscle.



1. C.N. 6 – Abducent nerve: SM.
   - Function: innervates the ipsilateral Lateral Rectus muscle. Participates in eye reflexes.
   - Nucleus: located internal to facial colliculus. Sends fibers to the contralateral oculomotor nucleus, through the Medial Longitudinal Fasciculus, for stimulation of Medial Rectus.
   - Nerve: exit through the Pontomedullary junction. Continue through the Prepontine cistern to the Cavernous Sinus, adjacent to internal carotid artery. Enter the orbit thru the Superior Orbital Fissure, and ends on the muscle.

Types of Movements:
**each kind of movement has very complicated system and pathway that is not mentioned here. Only the type of eye movements is mentioned.

1. Saccades – very fast and sharp movement between different points.
The point the eye stops on, to investigate, is called fixation points.

2. Smooth pursuit (מעכב) – following an object while it moves. This movement is slower, and requires smooth movement of the eye so the picture that formed will be accurate and clear. requires information from the cerebellum and vestibular nuclei.

3. nystagmus – movement with 2 components that happen when the head moves or the eye follows something that is moving and exits the visual field.
a. slow movement of the eye when it follows and object, or when the head spins and the eye fixes on a point.
b. fast movement of the eye when the object the eye followed left the visual field. The eye quickly jumps back to the middle.

Convergence movement (near triad) –

Happens when the eye moves to watch from distant to close object.
it is also called near triad because it Requires 3 simultaneous actions:
a. Eyes need to converge (both pupils become closer) by Medial Rectus muscles.
b. Lens need to increase curvature, by contraction of Ciliary muscle.
c. Pupil need to constrict, to increase depth of field.

Topic 9 – The Refractive elements of the Eye. Demonstration of the structures involved in Accommodation (also on the eye model)

Hain's 267, 389. Ross 900. Moore 897.

Refractive elements of the eye:

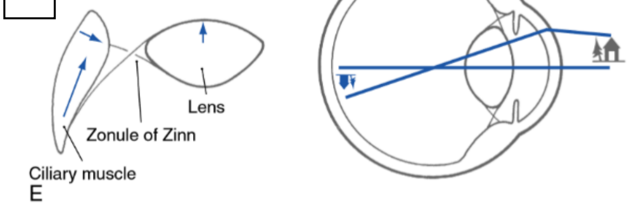
- Refraction – light rays break as they pass between different substances.
- The Refractive elements are the structures of the eye through which the light pass on its way to the retina – the Cornea, the Lens, the Aqueous Humour and the Vitreous Humour.

1. Cornea –
    - Transparent coat at the front of the eye. Protective function.
    - Part of the outer fibrous layer of the eye – Corneoscleral layer.
    - Continues with the conjunctiva – epithelium that cover the sclera. But not covered by it.
    - Its center is avascularised – has no vessels, to prevent blockage of light. The nutrients are received by diffusion.
    - Has thin nerve endings for the Corneal Reflex – when touching the eye, the eyelid closes.
    - It is the main refracting structure. Make the light change is angle in the biggest extant.

2. Lens –
    - The accommodating structure – enables us to look far or close by changing the focus. It can focus light from different distances on the retina.
    - No direct blood supply. it is supplied by the Vitreous Body and Aqueous Humour.
    - It is elastic structure, that changes its thickness according to need.
    - The focus of the lens is changed by making it flat or rounded. It is controlled by the Ciliary muscle, that connects the lens by a Suspensory ligaments called Zonule fibers:
        - ✈ When the ciliary muscle contracts, it releases tension of the Zonule fibers, so the anterior surface of the lens is becoming round – focusing the eye on near objects. Rounded lens is thicker, so it brakes the light rays more.
        - ✈ When the ciliary muscle Relaxes, it tenses the Zonule fibers, making the lens flat – focusing the eye on far objects.
    - The Ciliary muscle, part of the ciliary body, is activated by Short Ciliary nerve, from the Ciliary ganglion, controlled by the Edinger-Westphal nucleus (Parasympathetic).

- In addition to the lens, the pupil also changes in accommodation (but it is not a refractive structure):
    - the pupil is the space in the middle of the Iris. Its diameter can change, for regulating the amount of light that enter, and the depth of the field.
    - the changes are controlled by 2 muscles - Sphincter Pupillae and Dilator Pupillae. Together with the ciliary muscle, they are the 3 intraocular muscle.
        - ✈ In case of near object – the sphincter pupillae contracts, to make the pupil smaller, so less light enters the eye and the image is more acute. It has Parasympathetic innervation, from Edinger-Westphal nucleus.
        - ✈ In case of far object – the dilator pupillae contracts, to make the pupil bigger, so more light enters the eye. Sympathetic innervation, From the superior cervical ganglion.

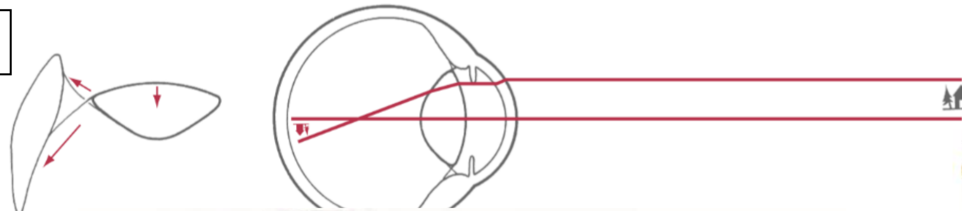
1

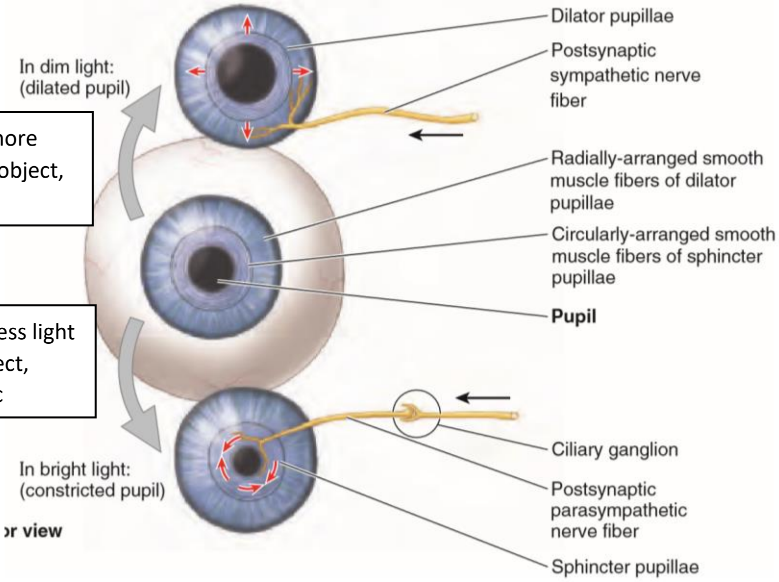

Lens
Zonule of Zinn
Ciliary muscle
E

1. Ciliary muscle contracts > release tension in Zonule fibers > rounding of anterior surface of lens > looking at a nearby target.

2. Ciliary muscle relaxes > increase tension in the Zonule fibers > lens flattens > looking at a distant target.

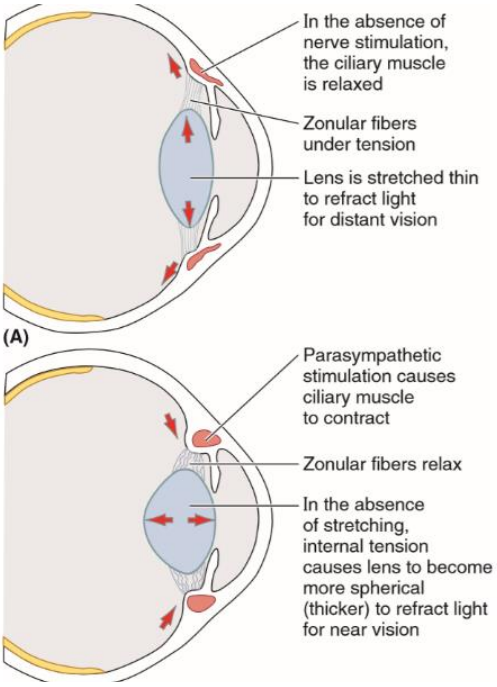
2




In dim light:
(dilated pupil)
Dilator pupillae
Postsynaptic sympathetic nerve fiber
Radially-arranged smooth muscle fibers of dilator pupillae
Circularly-arranged smooth muscle fibers of sphincter pupillae
Pupil
Ciliary ganglion
Postsynaptic parasympathetic nerve fiber
Sphincter pupillae
In bright light:
(constricted pupil)
or view

Dilated pupil – more light enters. Far object, Sympathetic.

Narrow pupil – less light enter. Close object, Parasympathetic

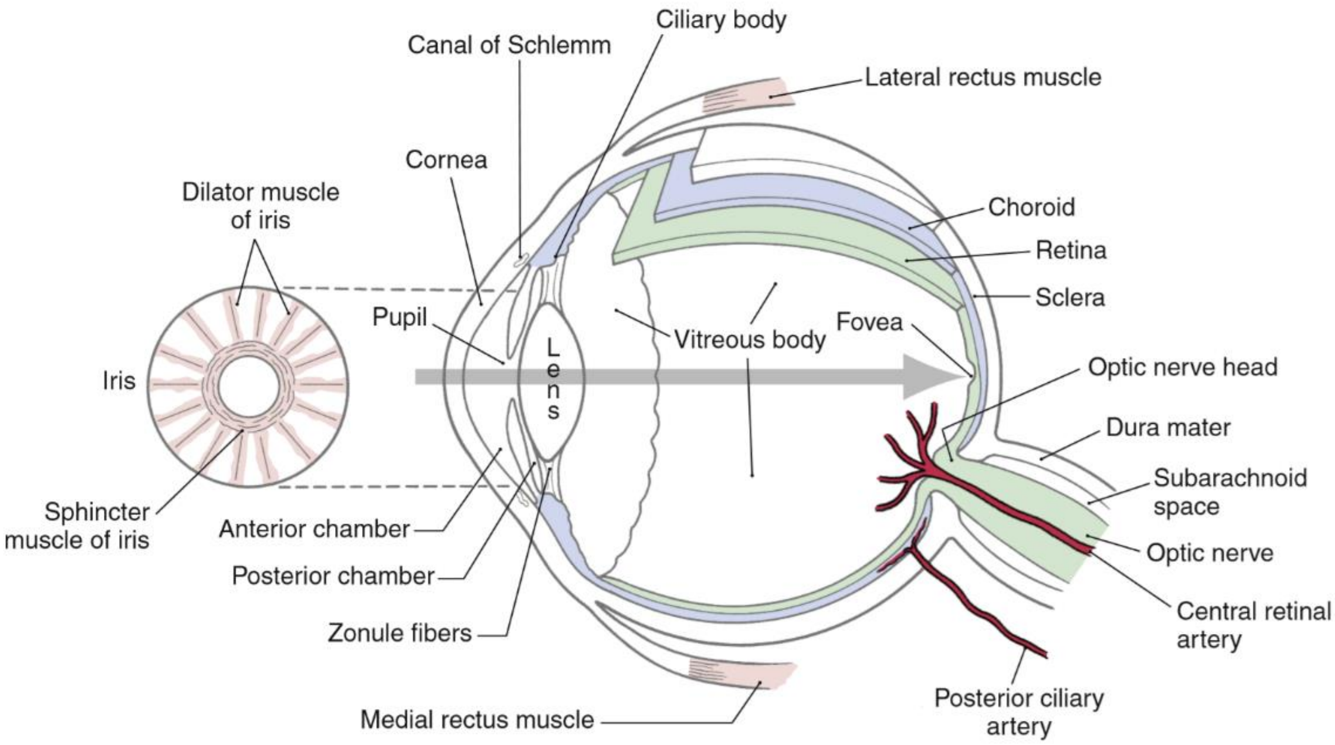

In the absence of nerve stimulation, the ciliary muscle is relaxed
Zonular fibers under tension
Lens is stretched thin to refract light for distant vision
(A)
Parasympathetic stimulation causes ciliary muscle to contract
Zonular fibers relax
In the absence of stretching, internal tension causes lens to become more spherical (thicker) to refract light for near vision

3. Fluid of the chambers of the eye – The eye has 3 chambers, filled with fluid, that also has little effect on the refraction.

1. The Anterior chamber – Between the cornea and the iris.
2. The Posterior chamber – between the iris and the lens.
3. The Vitreous chamber – between the lens and the retina.

- The Anterior and Posterior chambers – filled with a fluid, the Aqueous Humour:
  - Made by the Ciliary Body.
  - Secreted at the rim of Posterior chamber > flows through the pupillary opening into the Anterior chamber > drains through the canal of Schlemm that opens into the Iridocorneal angle. This canal encircles the eye, and it is also called Scleral Venous sinus.
  - The Aqueous Humour provides nutrients to lens and cornea, because they have no vessels.

- The Vitreous Chamber contains the Vitreous Body –
  - Gelatinous mass that fills the main space of the eyeball between the lens and the retina and supports them.
  - The fluid inside it is called Vitreous Humour. It refracts the light in a small extant.
  - Also used as shock absorber, keeps the lens in position and supply it with nutrients.


Ciliary body
Canal of Schlemm
Lateral rectus muscle
Cornea
Dilator muscle of iris
Choroid
Retina
Sclera
Pupil
Fovea
Vitreous body
L e n s
Iris
Optic nerve head
Dura mater
Subarachnoid space
Sphincter muscle of iris
Anterior chamber
Posterior chamber
Optic nerve
Central retinal artery
Zonule fibers
Medial rectus muscle
Posterior ciliary artery

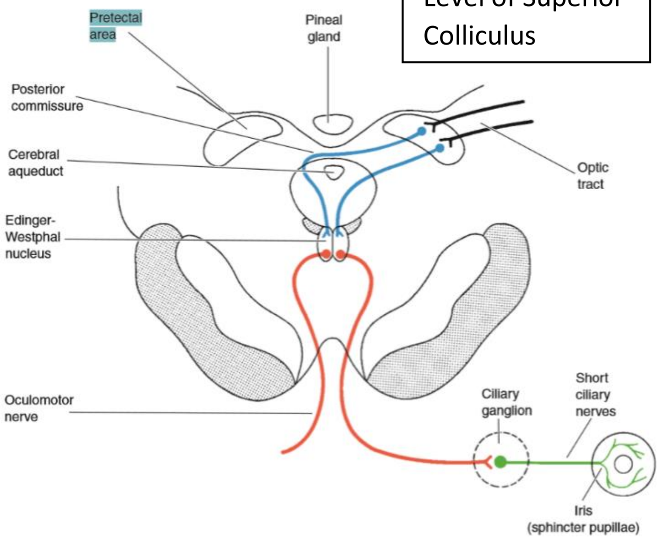
**we usually see the ciliary muscle in cross section in the drawings. However, it is actually a ring that surrounds the iris, so when it contracts the diameter becomes smaller, the Zonule fibers relax, and the lens become thickened by its own intrinsic flexibility – enables accommodation for near objects.

Additional information:

- Accommodation triad – 3 things required for accommodation for watching closer object:

1. Lens accommodation – lens become thicker.
2. Pupil constriction – makes the picture sharper.
3. Convergence – when the object is closer, the 2 medial rectus muscles make the eyes look more medially.

- Pupillary reflex:
    - The Pretectal area in the midbrain has neurons that are responsible for the Pupillary reflex – constriction of the pupils when the light is seen.
    - light enters from one eye also activates the reflex on the other eye, because the fibers connect the 2 sidesthrough the Posterior Commissure.
    - Edinger-Westphal nuclei of both sides are activated and induce constriction of the pupil by activating the Short Ciliary nerve, through the Ciliary ganglion.
    - The visual input comes from the optic tract.


Pretectal area
Pineal gland
Posterior commissure
Optic tract
Cerebral aqueduct
Edinger-Westphal nucleus
Oculomotor nerve
Ciliary ganglion
Short ciliary nerves
Iris (sphincter pupillae)

Level of Superior Colliculus

Topic 10 – Demonstration of the structures of the Visual Pathway and pupillary light reflex

Hain's 275

- The Visual pathway converts the light rays that enter the eye into the picture that we see.
- The pathway: Retina > Optic nerve > Optic chiasm > Optic tract > Lateral Geniculate nucleus > Optic radiation > Visual cortex.

1. Retina:

- Contains the Photoreceptor cells – rods and cons. Light rays hit them and cause cascade of electrical impulses in the cells of the retina.
- The eye can be divided into 2 axes – up-down, and nasal-temporal. Nasal part of each eye is the half closer to the nose (medial), and the temporal is the half closer to the temporal bone (lateral).
  The picture formed in the eyes is inverted and reversed by the lens – the inferior object appear on the superior retina, and object on the right appear on the left (temporal) surface of the left eye, and left (nasal) surface of the right eye. The brain adjusts it to form the real picture.
- The visual field is divided into 2 Hemi-fields – right or left half of the picture that is seen. Each eye catches the 2 hemi-fields.
- Finally, processes of the Ganglion cells that convey the input, enter through the Optic disc and form the Optic nerve.

2. Optic nerve:

- Cranial nerve 2.
- Enters the skull into the middle cranial fossa and exit through the Optic canal.
- It is myelinated and surrounded by arachnoid and dura mater.
- Supplied by the Ophthalmic artery that travels with it.

3. Optic chiasm:

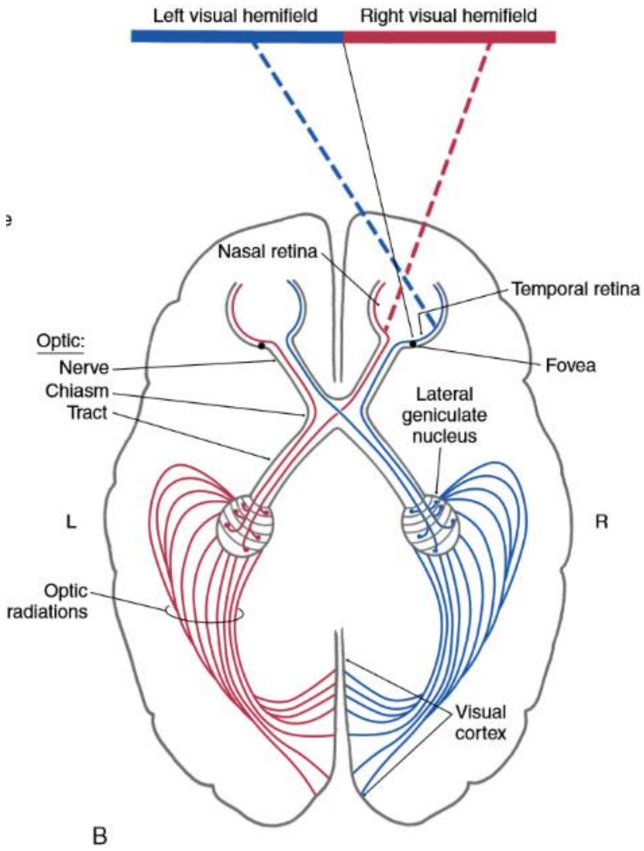
- Meeting of the 2 optic nerves.
- Location: anterior to the pituitary stalk. Inferior and anterior to the third ventricle.
  The Supraoptic recess of the third ventricle is found above it.
- In the optic chiasm, some fibers of the optic nerve cross to the other side –
  - Nasal half of retina (the half closer to nose) cross to the contralateral side.
  - Temporal half of retina (the half closer to temporal bone) remain on the ipsilateral side.
  - E.g. – if a cat walks on your left side, it is seen on the temporal surface of the right eye, and nasal surface of the left eye. Information from these areas will continue to the right optic tract.
  - Due to the crossing – left visual field project to the right hemisphere, and the opposite.
- Supplied by branches of Anterior communicating artery and A1 segment of Anterior Cerebral artery.

4. Optic tract:

- Continues posterior and laterally. It cross around the Crus Cerebri.
- Most fibers end in the Lateral Geniculate Bodies.
- About 10% of the fibers leave the optic tract and end in the Pretectal nucleus – for the Pupillary Reflex. This nucleus is anterior to Superior Colliculus and lateral to Posterior Commissure.

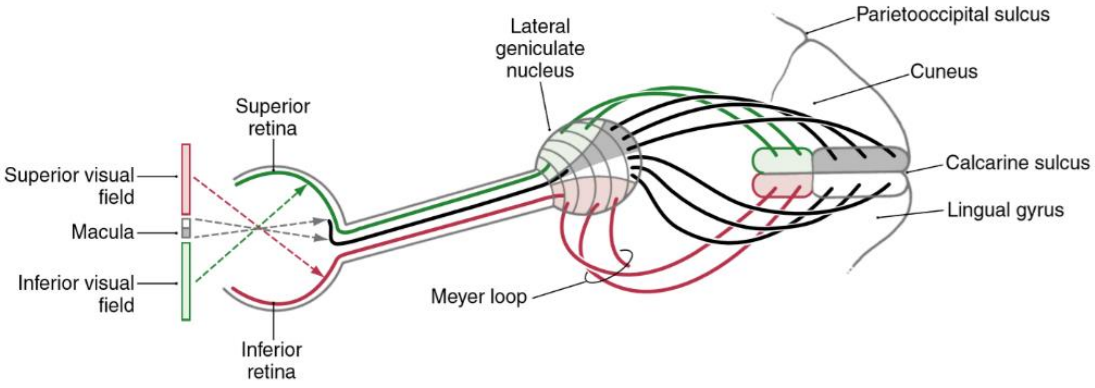
5. Lateral Geniculate nucleus:

- located inside the Lateral Geniculate Body, on the posterior part of Thalamus.
- Input: Optic tract. Enter on its anterior part.
- Output: Optic radiation. Exit through its posterior part.
- Little histology: the nucleus has 6 layers. Fibers from the ganglion cells end in these layers according to 2 rules:
  - On layer 1-2, information is mainly from Rods. In layer 3-6, information is mainly from Cons.
  - On layer 2,3,5 – information from the Temporal part of the retina of the Ipsilateral eye.
    On layer 1,4,6 – information from the Nasal part of the retina of the Contralateral eye.

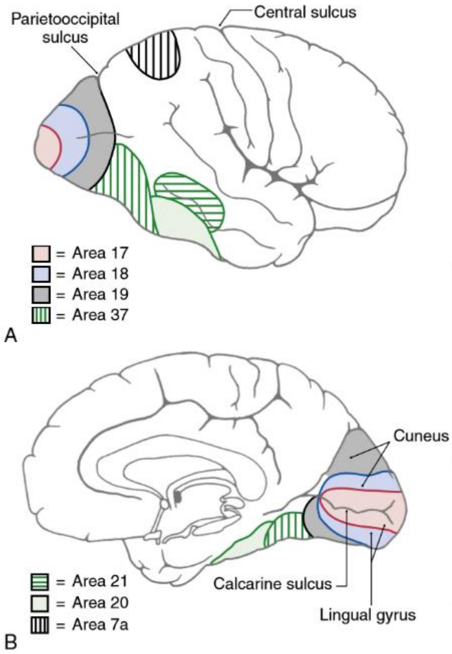

Left visual hemifield
Right visual hemifield
Nasal retina
Temporal retina
Optic:
Nerve
Chiasm
Tract
Fovea
Lateral geniculate nucleus
L
R
Optic radiations
Visual cortex
B

6. Optic radiation (Geniculocalcarine tract):

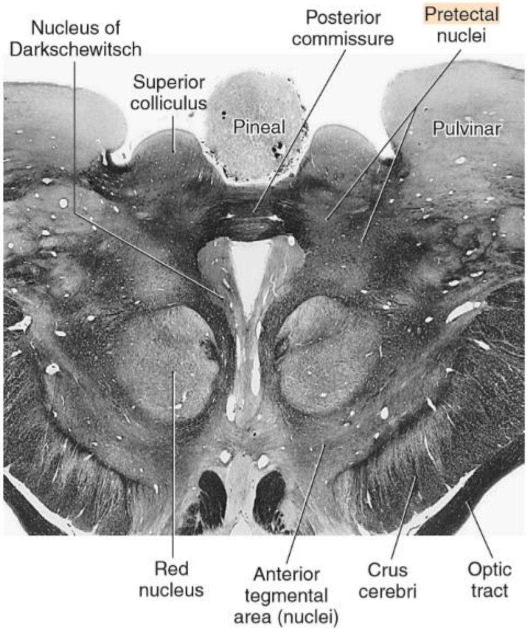
- Fibers from the cells of Lateral Geniculate nucleus, goes to the ipsilateral Primary Visual cortex, above and below the Calcarine sulcus.
- Divided into 3:
  - Fibers from Upper retina (lower visual field) pass in the lateral part of geniculate body, then they go directly back through the Retrolenticular limb of internal capsule (you can show it as the Posterior limb), and end in the Cuneus, above the Calcarine sulcus.
  - Fibers from Lower retina (upper visual field) pass in the medial part of geniculate body. They first go anteriorly through the white matter and form an arch called Loop of Meyer. Then they go posteriorly, to end in the Lingual gyrus, below the Calcarine sulcus.
  - Fibers from area of Macula – pass in the central part of Geniculate Body, and end on the posterior part of visual cortex.
- Blood supply – Middle and Posterior Meningeal arteries.

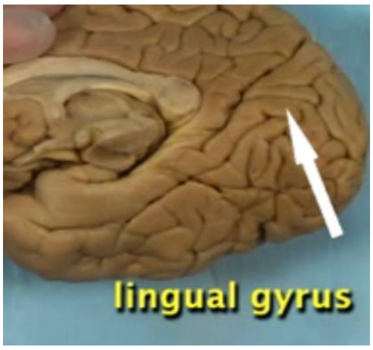

Lateral geniculate nucleus
Parietooccipital sulcus
Cuneus
Superior retina
Superior visual field
Macula
Inferior visual field
Inferior retina
Meyer loop
Calcarine sulcus
Lingual gyrus

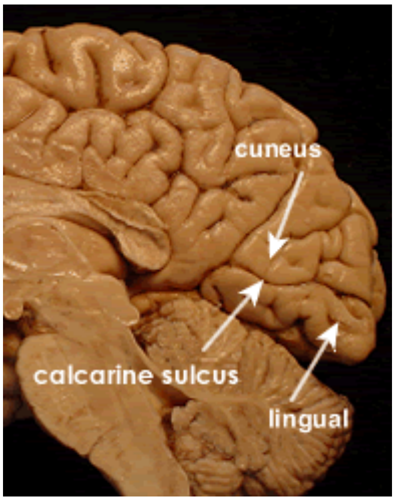
7. cortex:


Parietooccipital sulcus
Central sulcus
= Area 17
= Area 18
= Area 19
= Area 37
A
Cuneus
= Area 21
= Area 20
= Area 7a
Calcarine sulcus
Lingual gyrus
B

- Due to the decussation of the fibers in the optic chiasma – any object from one side of the visual field ends on contralateral cortex.
  E.g. – the cat on the left is analyzed on the right visual cortex.
- In the Occipital lobe the fibers end above and below the Calcarine sulcus:
  - Cuneus, on the upper bank of Calcarine sulcus, receives information from superior part of the retina.
    - It means that it gets the image from the inferior part of the contralateral Hemifield (objects that are actually located on the lower and opposite part of the picture we see).
  - Lingual Gyrus, on the lower bank of Calcarine sulcus, receives information from inferior part of the retina.
- The area closest to the Occipital pole receive information form the fovea – center of visual field. It is the primary visual cortex, and it receives the most acute picture.
- Primary visual cortex – also called Striate cortex, due to its histological appearance, that is made by 6 layers of cells (neocortex). It is Brodmann Area 17, found most posteriorly and receives the most accurate visual picture, from the area of macula.
- Visual association cortex – mainly Brodmann area 18 and 19, located more anteriorly. Each of them receive information from different parts of the retina. Responsible for recognition of objects, perception of color and motion.
- Other areas of visual association cortex – Brodmann area 37, on the inferior temporal cortex, and area 7 on the posterior part of parietal lobe, and areas 20 and 21 on the inferior and middle temporal gyri.


Nucleus of Darkschewitsch
Posterior commissure
Pretectal nuclei
Superior colliculus
Pineal
Pulvinar
Red nucleus
Anterior tegmental area (nuclei)
Crus cerebri
Optic tract


lingual gyrus


cuneus
calcarine sulcus
lingual

Topic 11 – Demonstration of the structures related to the corneal reflex.

Hain's 194. Moore 905.

- The corneal reflex is a protective reflex. The moment something touches the cornea – the eyelids automatically close.
- Efferent fibers – close the upper and lower eyelids. To do so, the orbicularis oculi should be activated. It is controlled by the facial nerve, through the facial plexus.
- Afferent fibers – receives information from the pain and touch receptors in the cornea, that sense foreign objects. The information is delivered by the long ciliary nerve, branch of the ophthalmic nerve. From there it continues to cell bodies in the trigeminal ganglion. From there – fibers continue to the spinal trigeminal nucleus.

- Pathway –
  1. Dust touches the cornea.
  2. Receptors senses it
  3. Long ciliary nerve is activated. Its continues to the Ophthalmic nerve sends the information to the trigeminal ganglion, that is found in the trigeminal impression.
  4. The trigeminal ganglion sends the information to the thalamus (trigeminothalamic fibers).
  5. Thalamus sends fibers to facial nuclei on both sides.
  6. Facial nucleus activates the facial nerve. Its branches activate the orbicularis oculi.
  7. The eyelid is shut.

- The long ciliary nerves –
  - Branch of the nasociliary nerve, which is a branch of the ophthalmic nerve that passes in the superior orbital fissure.
  - They don't pass through the ciliary ganglion.
  - Have 2 functions:
    - ✈ Gives sympathetic innervation to the Dilator pupillae muscle.

- Transmit sensory information from the Cornea and Iris.

Topic 12 – Demonstration of the structures related to the oculopalpebral (blink) reflex.

- This reflex is similar to the corneal reflex. In this case, a person blinks as response to visual information, as some object flying fast toward him.
- The sensory information comes from the visual system.
- From the superior colliculus, the information projects to the facial motor nucleus, that will close the eye.
- The superficial layer of the superior colliculus is visual sensory. It is a target of retinal axons.
- The intermediate layer of it is visual motor.
    - Input: substantia nigra and frontal eye fields.
    - Output: gives fibers to the medial longitudinal fasciculus and vertical and horizontal gaze centers.

Topic 13 – Demonstration of the structures related to the vestibuloocular reflex.

Hain's 307, 387

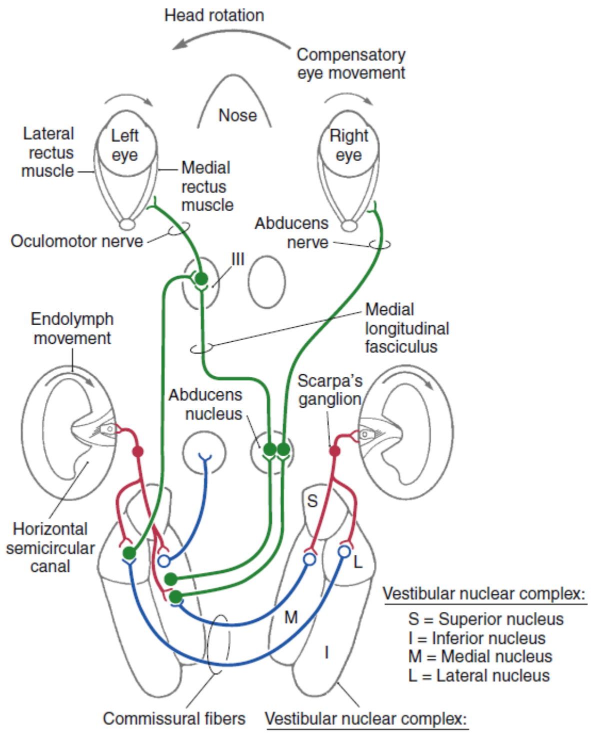
- The vestibuloocular reflex stabilizes the eye movement while the head moves. Fix the eye on the same spot.
- It is related as compensatory reflex – the eye moves in equal magnitude and opposite direction to the head movement.
- The head movement is perceived by the vestibular system.
    - The Crista in the anterior, posterior and lateral semicircular canals sense the movement of the head on the 3 axis.
    - In addition – the saccule and utricle sense the static movement.

- Each axis of eye movement receives input from different structures –
    - Vertical – vertical (anterior) semicircular duct and saccule.
    - Horizontal – horizontal (lateral) semicircular duct and utricle.
    - Torsional movement – by the vertical semicircular canal and the utricle.

- Example of horizontal eye movement –
    - horizontal semicircular canal sends impulse to the medial and lateral vestibular nuclei.
    - Vestibular nuclei send impulse trough the medial longitudinal fasciculus to few locations:
        - Contralateral abducent nucleus. Activate the lateral rectus muscle on the same side of the nucleus.
        - Contralateral oculomotor nucleus to activate the medial rectus muscle of the other eye.
        - Inhibitory signal to the ipsilateral lateral rectus muscle is activated and the eye goes left.
- Nystagmus appears in fast rotational movement, when the eye cant follow the object. It has a slow phase –following, and a fast phase – eye jumping.

During a **leftward head turn:**

1. excitatory signals from the left horizontal semicircular canal afferents increase the firing rate of neurons in the left vestibular nuclei.
2. At the same time, inhibitory signals from the right vestibular nuclei are decreased via commissural neurons.
3. Neurons in the left vestibular nuclei then excite both the contralateral abducens motor neurons and interneurons, which in turn produce contraction in the right lateral rectus and the left medial rectus muscles
4. The resulting rightward eye movement. keeps the object of interest on the fovea.
5. left lateral rectus and right medial rectus eye muscles are inhibited.


Head rotation
Compensatory eye movement
Nose
Lateral rectus muscle
Left eye
Right eye
Medial rectus muscle
Abducens nerve
Oculomotor nerve
III
Medial longitudinal fasciculus
Endolymph movement
Abducens nucleus
Scarpa's ganglion
Horizontal semicircular canal
S
L
M
I
Vestibular nuclear complex:
S = Superior nucleus
I = Inferior nucleus
M = Medial nucleus
L = Lateral nucleus
Commissural fibers
Vestibular nuclear complex:

Topic 14 – Demonstration of the structures of the Auditory Pathway and acoustic reflexes (tensor reflex, stapedius reflex, olivocochlear reflex)

Hain's 289.

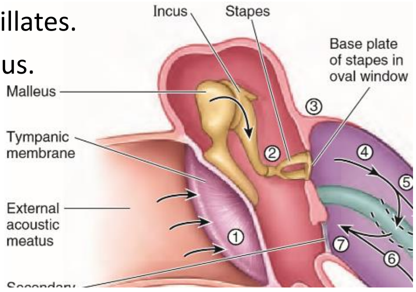
- The Auditory Pathway converts the sound wave that reach the ear into a sensible sound.
- Sound is made by vibration of substances.
- Frequency – the pitch, High or low sound. Measured in Hertz (Hz). Human range: 50-16,000 Hz.
- Intensity – strong or silent sound. Measured in Decibels (Db). Normal conversation: 50 Db. sound above 120 Db can cause discomfort and damage.
- The Pathway: External ear > Tympanic membrane > Ossicles > Oval window > around the cochlear duct > Organ of Corti > Cochlear nerve > Cochlear nuclei > Superior Olive and Lateral Lemniscus > Inferior Colliculi > Brachium of Inferior Colliculi > Medial Geniculate Body > Auditory Radiation > Auditory Cortex.

1. External Ear:

- The Auricle (Pinna) catches the sound wave.
- The external acoustic meatus channels the sound toward the Tympanic Membrane.

2. Middle Ear:

- The Tympanic Membrane converts the air waves into mechanical movement.
  As the tympanic membrane vibrates, the Malleus, which is attached to it, oscillates.
- The oscillation passes through the Ossicles bones. The malleus Moves the Incus. the Incus moves the Stapes.
- The Stapes moves the Oval Window.
- The Ossicles and the Tympanic Membrane amplify the signal.

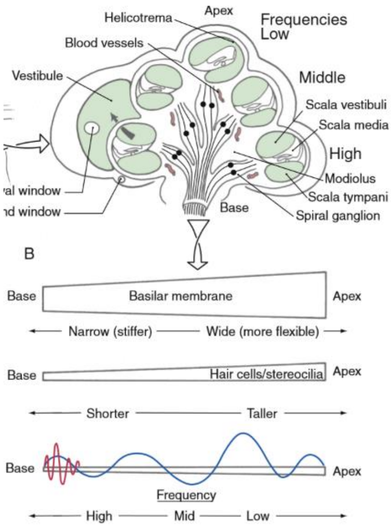


3. Inner Ear:

- The oval window transmits the mechanic movement of the bone into wave in a fluid.
  As the oval window moves, it forms waves in the perilymph. These waves continue towards the cochlea, where they enter to the Scala Vestibule (continues from the Vestibule).
- The wave continues to the superior end of the cochlear spiral, and passes in the Helicotrema into the Scala Tympani.
- In the Scala Tympani, waves continue and end in the Round Window, that releases the pressure formed from the waves back into the middle ear.
- The waves in the Scala tympani hit the Basilar Membrane, on which the Organ of Corti is found, and it vibrates up and down according to the waves.
    - Membrane at the apex is more flexible, so it is affected by Lower frequencies.
    - At the base, the membrane is less flexible, so it is affected by Higher frequencies.
- The Inner and Outer Hair Cells are compressed between the basilar and Tectorial Membrane. As they compress, they are depolarized, and release neurotransmitter, that activates the peripheral processes of the neurons of the Spiral Ganglion, that are found in the Modiolus.
- From the spiral ganglion, the central processes of the cells form the Cochlear nerve.
- Blood supply – Labyrinthine artery, branch of AICA or the Basilar artery.

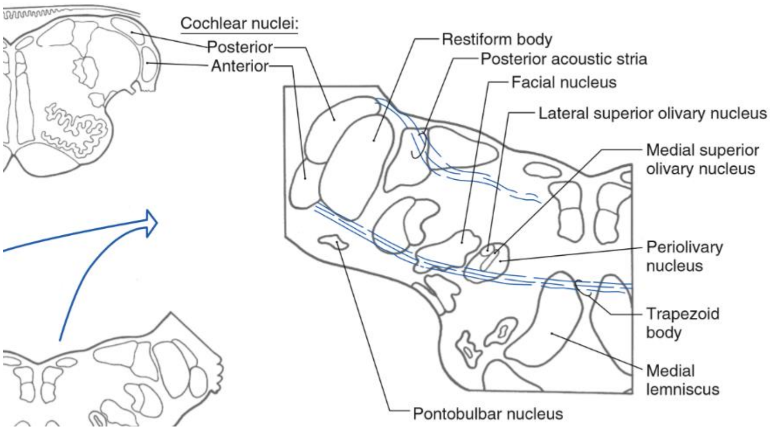
4. Cochlear nerve:

- Part of Vestibulocochlear nerve. Cranial nerve 8.
- Formed by the central processes of the cells of Spiral Ganglion, located in the Modiolus.
- The ganglion has 2 cell types. Type 1: less sound sensitive but more accurate. Type 2: more sound sensitive (can hear quite things) but less accurate (doesn't distinguish well between frequencies).
- They enter the cranial cavity through the Internal Acoustic Meatus.
- The Vestibulocochlear nerve passes through the Cerebellopontine angle, and enter the brain stem through the Pons-Medullary junction.
- The Cochlear nerve ends in the Cochlear nuclei.


Helicotrema
Apex
Frequencies
Low
Blood vessels
Vestibule
Middle
Scala vestibuli
Scala media
High
Modiolus
Scala tympani
Spiral ganglion
al window
d window
Base
B
Base
Basilar membrane
Apex
Narrow (stiffer)
Wide (more flexible)
Base
Hair cells/stereocilia
Apex
Shorter
Taller
Base
Apex
Frequency
High
Mid
Low

5. Cochlear nuclei:

- the Anterior and Posterior Cochlear nuclei are located at the lateral part of Ponto-Medullary junction, posterior to the inferior cerebellar peduncle.
- Fibers of cochlear nerve end on ipsilateral Anterior and Posterior cochlear nuclei.
- From the Posterior nucleus – fibers ascend and cross into the Lateral Lemniscus of the Contralateral side, through the Dorsal Acoustic Stria.
- From the Anterior nucleus –
  1. Some fibers go to the Ipsilateral Superior Olivary nucleus.
  2. Some fibers cross through the Trapezoid body to the Contralateral Superior Olivary Nucleus.
  3. Some fibers ascend directly to the Contralateral Lateral Lemniscus, through the Dorsal Acoustic Stria.
- Blood supply – Basilar artery.


Cochlear nuclei:
Posterior
Anterior
Restiform body
Posterior acoustic stria
Facial nucleus
Lateral superior olivary nucleus
Medial superior olivary nucleus
Periolivary nucleus
Trapezoid body
Medial lemniscus
Pontobulbar nucleus

6. Superior olivary nucleus:

- Location: near the Facial motor nucleus.
- Input: Anterior cochlear nuclei of both sides.
- Output: Lateral Lemniscus.
- Responsible for binaural information – used to process sound from the 2 ears, and analyse the origin of sound (left or right, far or close).
- The 2 nuclei communicate with each other.

7. Inferior Colliculus:

- Input: fibers from Posterior and Anterior Cochlear nuclei, and from the Superior Olivary nucleus, through the Lateral Lemniscus (has anterior and posterior nuclei).
- Output: Medial Geniculate Body through the brachium of inferior colliculus.
- All ascending auditory pathways terminate in it. It is responsible mainly for monaural information – sounds at a single ear. It is the normal information that refers to intensity and pitch of sound.

Lemniscal trigone = trigone of lateral lemniscus. Small area below the inferior colliculus. Inner to it passes the lateral lemniscus.

8. Medial Geniculate Nucleus:

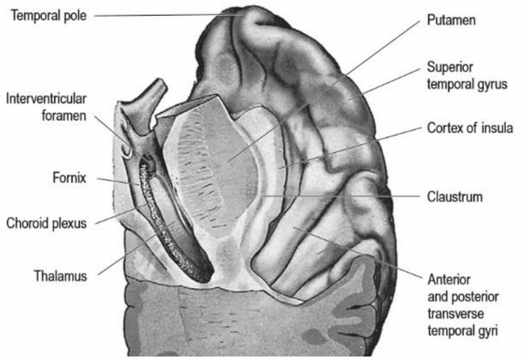
- In the medial geniculate body, On the posterior part of thalamus, between the Lateral Geniculate Body and the Pulvinar.
- Input: Inferior Colliculus.
- Output: Auditory cortex.

9. Internal capsule:

- Fibers from Medial Geniculate Body pass through the Sublenticular limb of Internal Capsule (you can show the posterior limb) in a bundle of fibers named Auditory Radiation, that ends on cortex.

10. Auditory cortex:

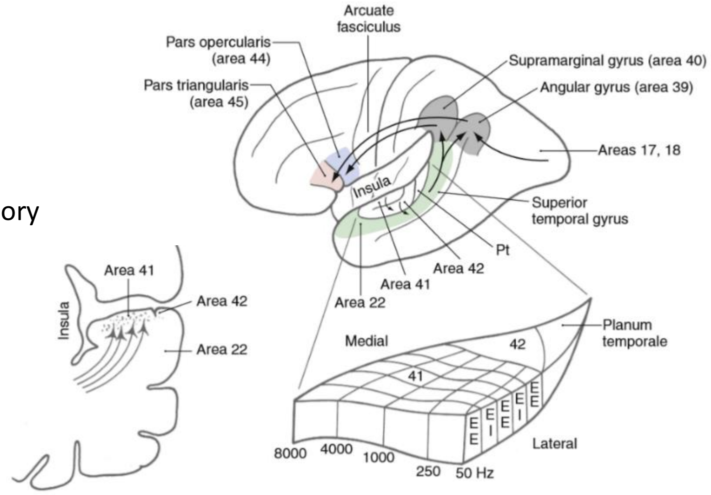
- Location: mainly on the Transverse gyri of Heschl. On the part of temporal lobe inside the lateral sulcus, covered by the opercula.
- Primary auditory cortex: Brodmann area 41.
  - on the Anterior transverse temporal gyrus, may extend to the posterior gyrus.
- Secondary auditory cortex: Brodmann area 42.
  - On the Posterior transverse temporal gyrus and Planum Temporale (area posterior to the transverse gyri).

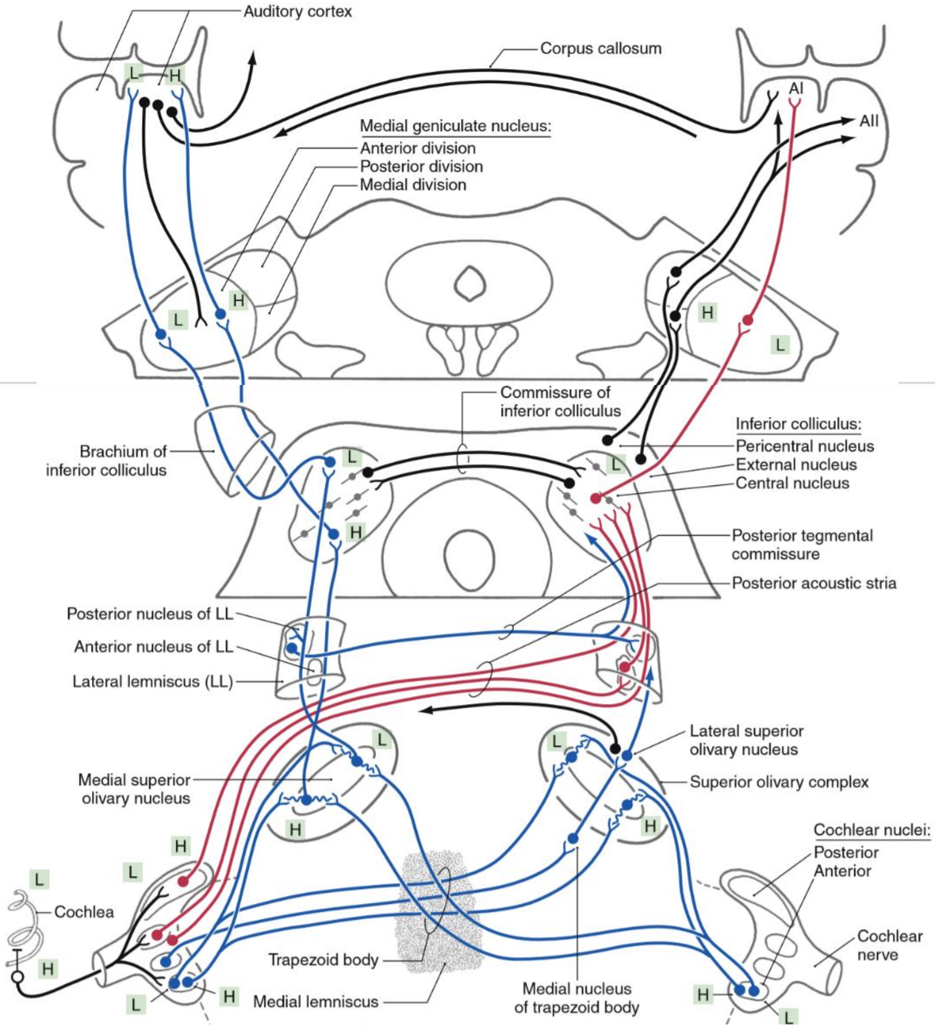

Temporal pole
Interventricular foramen
Fornix
Choroid plexus
Thalamus
Putamen
Superior temporal gyrus
Cortex of insula
Claustrum
Anterior and posterior transverse temporal gyri

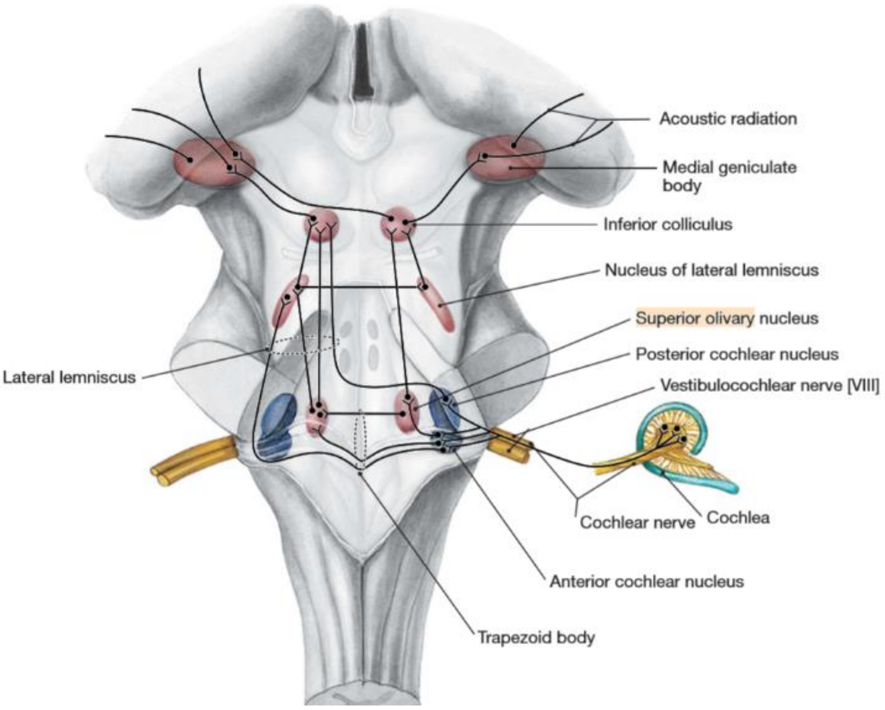
- Auditory association cortex:
  - On the superior temporal gyrus.
  - Connected to the primary auditory cortex by Arcuate Fasciculus.
- The temporal cortices of the 2 hemispheres communicate through the Corpus Callosum.

- Wernicke area:
  - Speech receptive area. Area 22. On the Planum Temporale and Superior Temporal Gyrus.
  - Also included – parts on the parietal lobe that are important for reading and writing – Angular gyrus (area 39) and Supramarginal gyrus (area 40).
  - Responsible for language understanding. Usually larger on the left hemisphere.

- Broca area:
  - Found on pars Opercularis (area 44) and pars Triangularis (area 45) of Inferior Frontal Gyrus.
  - Responsible for motor expression by speech.
  - Connected to the primary and association auditory cortex through the arcuate fasciculus.


Arcuate fasciculus
Pars opercularis (area 44)
Pars triangularis (area 45)
Supramarginal gyrus (area 40)
Angular gyrus (area 39)
Areas 17, 18
Insula
Superior temporal gyrus
Pt
Area 42
Area 41
Area 22
Area 41
Area 42
Area 22
Insula
Medial
42
41
Planum temporale
E
E
E
I
E
E
I
E
E
Lateral
8000
4000
1000
250
50 Hz


Auditory cortex
L
H
Corpus callosum
AI
AII
Medial geniculate nucleus:
Anterior division
Posterior division
Medial division
H
L
H
L
Commissure of inferior colliculus
Brachium of inferior colliculus
L
H
L
Inferior colliculus:
Pericentral nucleus
External nucleus
Central nucleus
Posterior tegmental commissure
Posterior acoustic stria
Posterior nucleus of LL
Anterior nucleus of LL
Lateral lemniscus (LL)
L
L
Lateral superior olivary nucleus
Medial superior olivary nucleus
Superior olivary complex
H
H
H
L
L
Cochlea
H
Cochlear nuclei:
Posterior
Anterior
Cochlear nerve
Trapezoid body
L
H
Medial lemniscus
Medial nucleus of trapezoid body
H
L


Acoustic radiation
Medial geniculate body
Inferior colliculus
Nucleus of lateral lemniscus
Superior olivary nucleus
Posterior cochlear nucleus
Vestibulocochlear nerve [VIII]
Lateral lemniscus
Cochlear nerve
Cochlea
Anterior cochlear nucleus
Trapezoid body

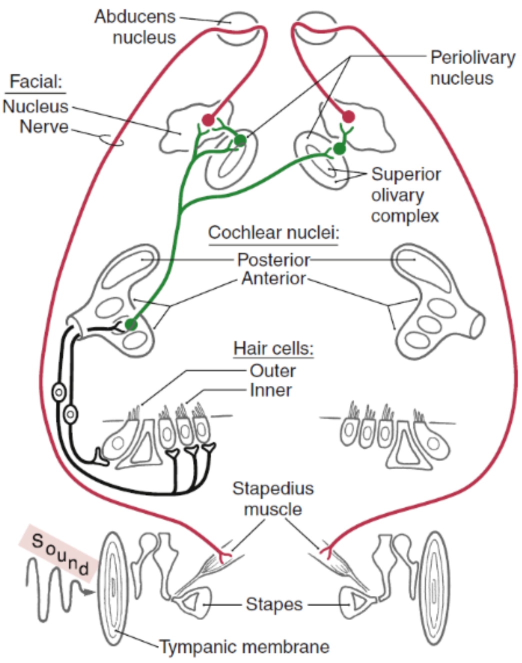
Middle Ear Reflex (Tensor reflex + Stapedius reflex):
Hain's 299

- 2 Functions:
    - Protecting the inner ear from loud sounds that have long duration (Because of the timing of the response).
    - Serve to dampen the speaker's own voice.
- After auditory input travels toward the brain, signals are sent back to activate the muscles.

- Involves 2 muscles:
    - Stapedius –
        - ✈ Controlled by the facial motor nucleus and innervated by the nerve to stapedius.
        - ✈ It is the smallest muscle in the body, extending from the pyramidal eminence on the posterior wall of the inner ear, to the neck of the stapedius bone.
        - ✈ When eating and talking the muscle pulls the stapedius bone, so person doesn't hear himself eat or talk.
    - Tensor tympani –
        - ✈ Controlled by the trigeminal motor nucleus and innervated by

- The 2 motor neurons that control the muscles are associated with the superior olivary complex, from which they receive auditory input. It gives the sensory limb of the reflex.

Inner ear reflex


Abducens nucleus
Facial:
Nucleus
Nerve
Periolivary nucleus
Superior olivary complex
Cochlear nuclei:
Posterior
Anterior
Hair cells:
Outer
Inner
Stapedius muscle
Sound
Stapes
Tympanic membrane

Olivocochlear bundle:

- Function: After auditory input travels toward the brain, efferent feedback to hair cells is sent to the inner ear to effect sensitivity and frequency selectivity, by effecting the height and stiffness of stereocilia of the outer hair cell. This would form amplification of specific tones.
- Communications – efferent information is delivered from the superior olivary complex by the olivocochlear bundle in the vestibulocochlear nerve:
    - Lateral olivocochlear efferent – to ipsilateral inner hair cells.
    - Medial olivocochlear efferent – to bilateral outer hair cells.

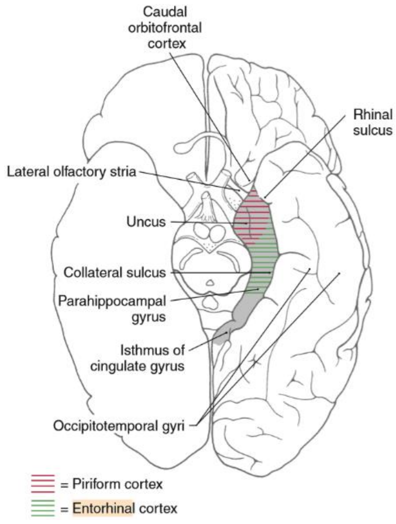
Topic 15 – Demonstration of the anatomical structures of the Limbic System

Hain's 217, 431. Barr's 269.

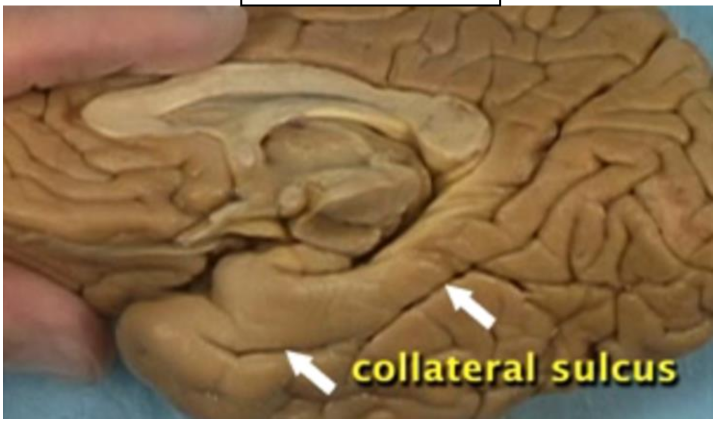
- Function: memory, emotional process, olfaction and cognitive functions.
- All sensory information passes through the limbic system, to detect emotional content. If something is emotional, it activates A.P. for longer time – emotional content has stronger effect.
- It is comprised of the Limbic Lobe + nuclei in the diencephalon and telencephalon. some books don't consider the limbic lobe as a lobe.
- All the structures have many inputs and outputs. Some are mentioned here.
- Components of the limbic system are considered Archicortex (3 cell layers) and Paleocortex (3-5 cell layers). This indicate the ancient origin of the limbic system, relative to the cortex, that is newer – Neocortex (6 cell layers).

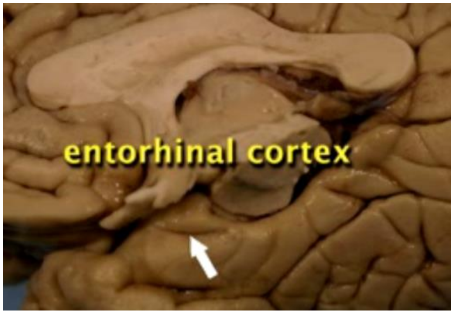
Limbic Lobe:

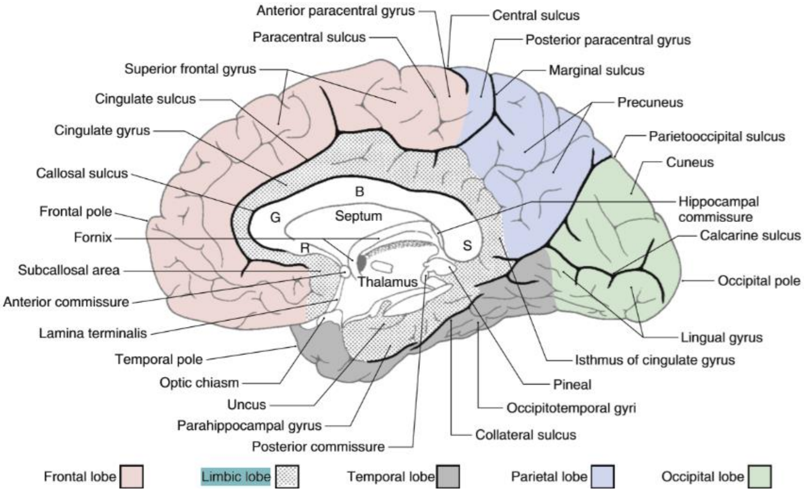
- Cingulate gyrus – surrounds the Corpus Callosum. Isthmus of the cingulate gyrus is at its posterior part.
- Cingulate sulcus – surrounded by the Cingulate gyrus. it is the superior border of the lobe.
- Callosal sulcus – between the cingulate gyrus and corpus callosum.
- Parahippocampal gyrus – inferior part. Histologically called the Entorhinal cortex.
- Uncus – anterior to Parahippocampal gyrus. Histologically called the Piriform cortex.
- Collateral sulcus – the inferior border of the lobe, between the Parahypocampal gyrus and the Temporal lobe.


Caudal orbitofrontal cortex
Rhinal sulcus
Lateral olfactory stria
Uncus
Collateral sulcus
Parahippocampal gyrus
Isthmus of cingulate gyrus
Occipitotemporal gyri
= Piriform cortex
= Entorhinal cortex

Collateral sulcus – border of parahippocampal gyrus.

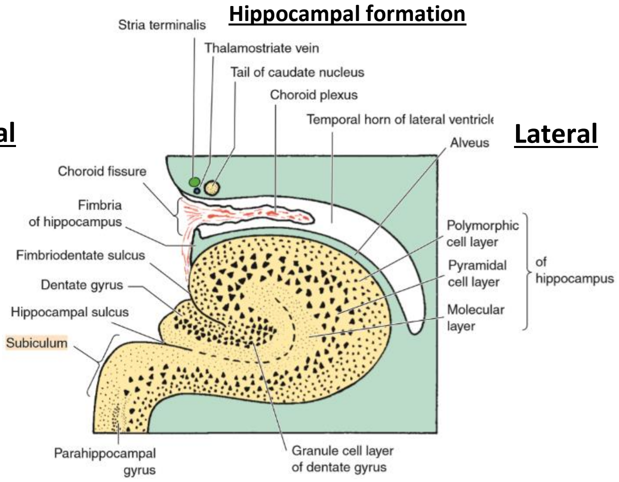

collateral sulcus


entorhinal cortex

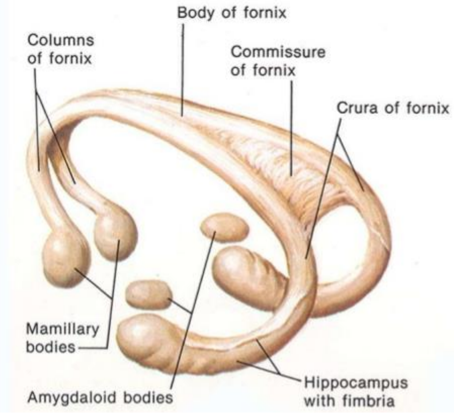

Anterior paracentral gyrus
Central sulcus
Paracentral sulcus
Posterior paracentral gyrus
Superior frontal gyrus
Marginal sulcus
Cingulate sulcus
Precuneus
Cingulate gyrus
Parietooccipital sulcus
Cuneus
Callosal sulcus
B
Hippocampal commissure
Frontal pole
G
Septum
Calcarine sulcus
Fornix
R
S
Subcallosal area
Thalamus
Occipital pole
Anterior commissure
Lamina terminalis
Lingual gyrus
Temporal pole
Isthmus of cingulate gyrus
Optic chiasm
Pineal
Uncus
Occipitotemporal gyri
Parahippocampal gyrus
Collateral sulcus
Posterior commissure
Frontal lobe
Limbic lobe
Temporal lobe
Parietal lobe
Occipital lobe

Structures of the Limbic System:

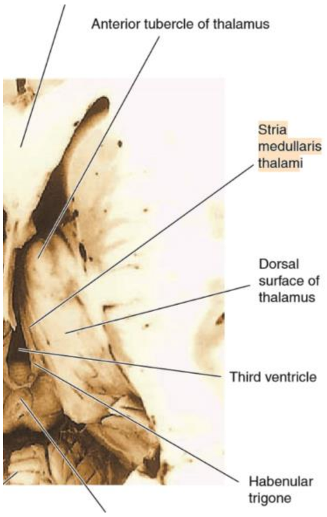
- Amygdala – Anterior border of the inferior horn of lateral ventricle.
  - Has few nuclei that are not really seen in the specimen: Central, Cortiomedial, Basolateral.
  - Function: olfaction processing, recent memory and fear.
  - Output:
    1. Stria Terminalis extends medial to the caudate nucleus and on the dorsal thalamus with the terminal vein. ends in the hypothalamus.
    2. Dorsomedial nuclei of thalamus.
    3. Hippocampus.


Hippocampal formation
Medial
Lateral
Stria terminalis
Thalamostriate vein
Tail of caudate nucleus
Choroid plexus
Temporal horn of lateral ventricle
Alveus
Choroid fissure
Fimbria of hippocampus
Fimbriodentate sulcus
Dentate gyrus
Hippocampal sulcus
Subiculum
Polymorphic cell layer
Pyramidal cell layer
Molecular layer
of hippocampus
Parahippocampal gyrus
Granule cell layer of dentate gyrus

- Hippocampal formation:
  - Hippocampus – responsible for short term memory. from it the Alveus layer (layer of hippocampus that faces into the lateral ventricle) give raise to the fimbria of hippocampus, that become the fornix.
    Function: long term memory.
  - Subiculum – lateral edge of Parahippocampal gyrus. Receive fiber from the amygdala.
  - Dentate gyrus – medial edge of hippocampus.


Body of fornix
Columns of fornix
Commissure of fornix
Crura of fornix
Mamillary bodies
Amygdaloid bodies
Hippocampus with fimbria

- Fornix – not a nucleus or part of cortex, but it is white matter that communicate between the Hippocampal Formation and mammillary body, Septal nuclei and other structures.
  Serves as output. Also has the Hippocampal Commissure (also called Commissure of Fornix) on its back – these are fibers that communicate between Hippocampus of the 2 sides.
  Composed of Crus (posterior), Body (beneath the Corpus Callosum) and Columns (anteriorly, posterior to the anterior commissure).
- Substantia Innominata – part of the basal ganglia.
  Location: internal to the Anterior Perforated Substance, inferior to the Anterior Commissure.


Anterior tubercle of thalamus
Stria medullaris thalami
Dorsal surface of thalamus
Third ventricle
Habenular trigone

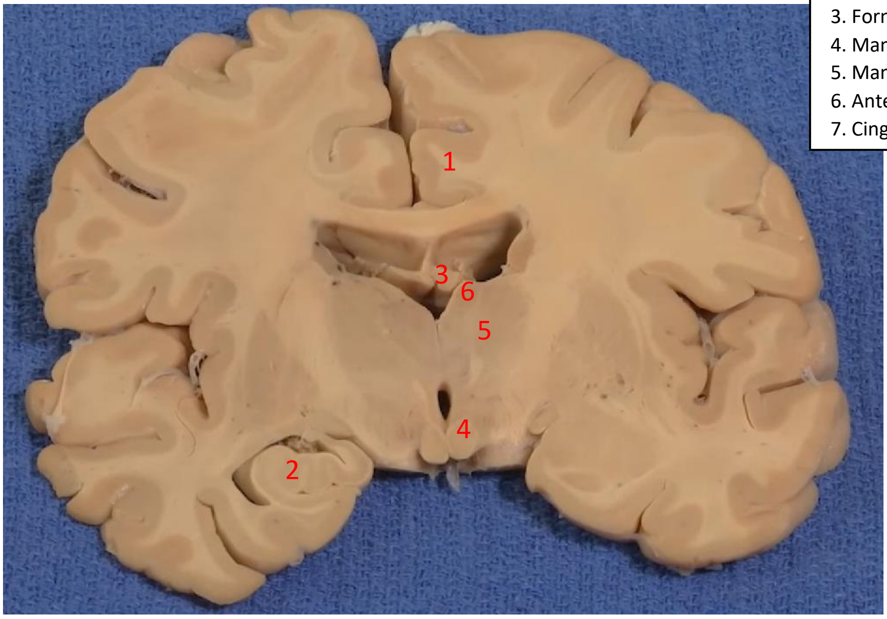
- Nucleus Accumbens – part of the basal ganglia.
  located where the Head of Caudate is continuous with the Putamen.
  Function: addiction and pleasure seeking behaviour.
- Septal nuclei – few nuclei in the Septum Pellucidum, anterior to Anterior Commissure. Connect through the Stria Medullaris Thalami (on the medial thalamus) to the Habenular nuclei.
- Medial Forebrain Bundle – passes through the lateral part of hypothalamus and connect some parts of the limbic system, as nucleus Accumbens, to other structures.

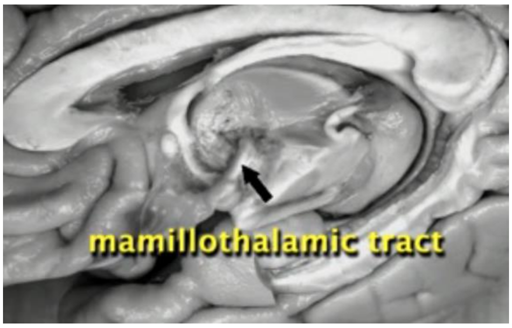
Papez circuit:

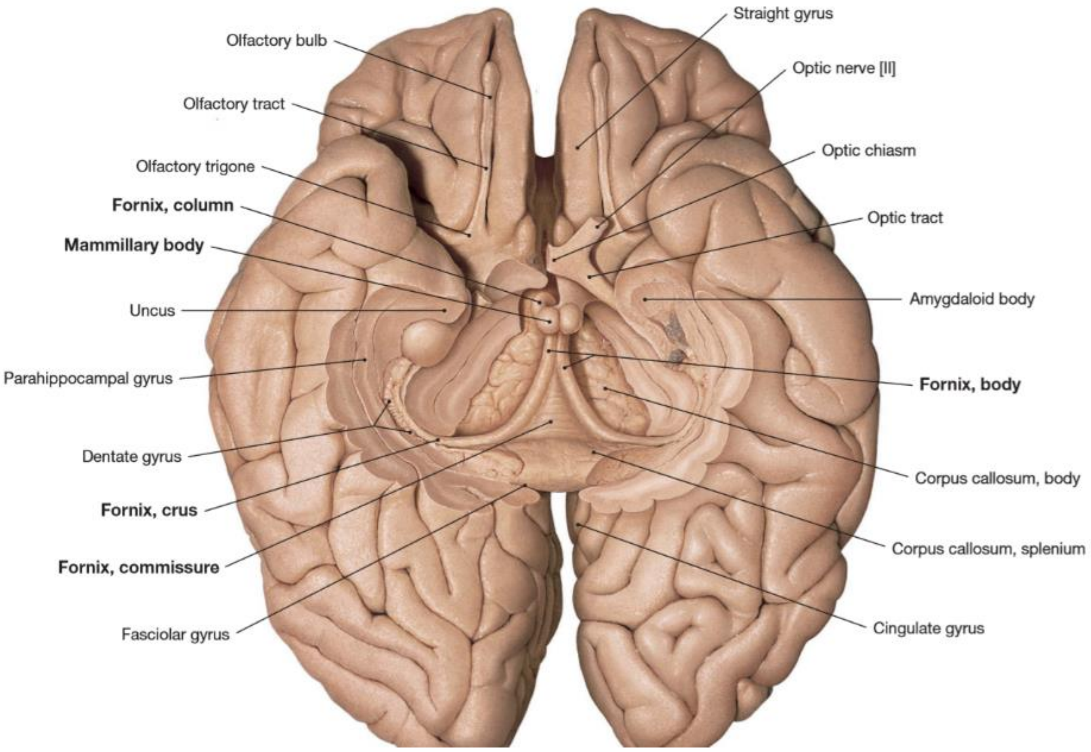
- It is one of the pathways of the limbic system, and the first that showed that the limbic system effects behaviour, and not only on part of the olfaction system.
- Basically it is a circuit, so it can begin from any point, but it is better to say it begins from the Hippocampus.
- It shows the pathway of emotion processing: Cingulate gyrus > Cingulum (association fibers) > Hippocampal formation > Fornix > Mammillary body > Mammilothalamic tract > Anterior nucleus of Thalamus > Cingulate gyrus.

Papez "loop" = Papez circuit utha youtube video, hypothalamus 1000

1. Cingulate gyrus
2. Hippocampus
3. Fornix
4. Mammillary body
5. Mammilothalamic tract
6. Anterior nucleus of Thalamus
7. Cingulate gyrus




mamillothalamic tract

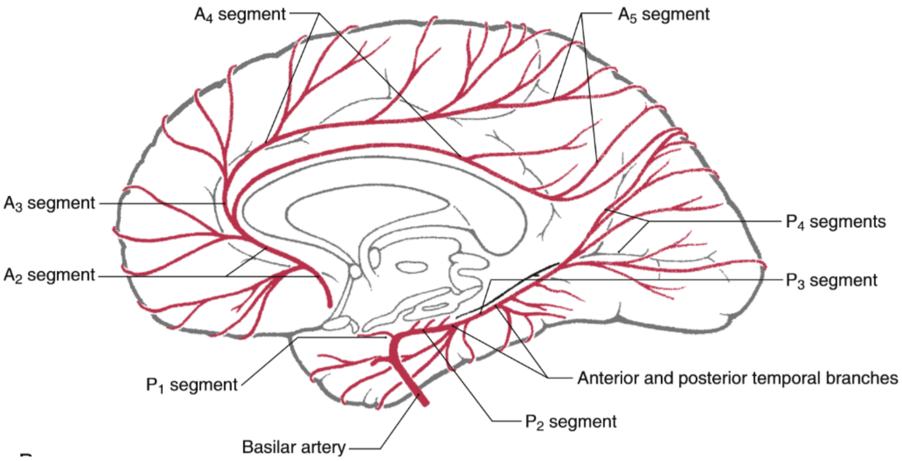

Olfactory bulb
Olfactory tract
Olfactory trigone
Fornix, column
Mammillary body
Uncus
Parahippocampal gyrus
Dentate gyrus
Fornix, crus
Fornix, commissure
Fasciolar gyrus
Straight gyrus
Optic nerve [II]
Optic chiasm
Optic tract
Amygdaloid body
Fornix, body
Corpus callosum, body
Corpus callosum, splenium
Cingulate gyrus

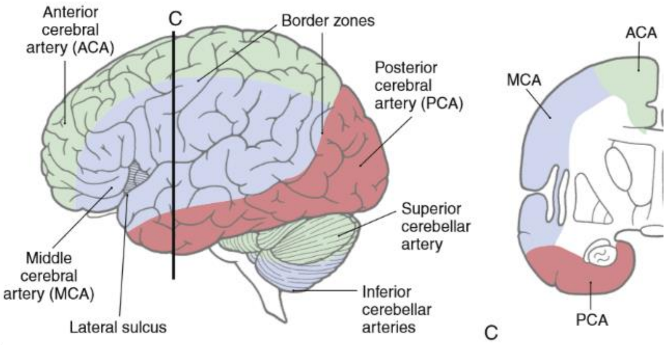
Topic 16 – Demonstration of the areas of the Brain supplied by the Anterior Cerebral Artery (names of branches are optional)

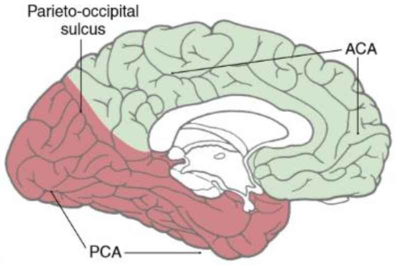
Hain's 109. Barr's 371.

- Anterior Cerebral artery (ACA) – originate from the internal carotid artery. Smaller then Middle Cerebral artery.
- supply mainly the medial surface. Also supply the superior margin of the lateral surface.
- divide into 5 segments, A1-A5, named according to their position:
  - A1 – Precommunicating segment. From ICA to anterior communicating artery.
    - Go anteriorly, above optic chiasm. Connect the other side by the communicating artery.
  - A2 – Infracallosal segment. From anterior communicating to genu of corpus callosum.
    - Supply: orbital gyri (Orbitofrontal a.) and frontal pole (Frontopolar a.).
  - A3 – Precallosal segment – pass in front of the genu. **in the department they call it Pericallosal.
    - Give Calloso-marginal artery and internal frontal branches.
  - A4 – Supracallosal segment – pass above the Corpus Callosum.
    - Supply the medial surface of hemisphere.
  - A5 – Postcallosal segmet – found posterior to the corpus callosum, at the Parieto-occipital sulcus. Supply the medial surface of hemisphere.

Medial surface


A_4 segment
A_5 segment
A_3 segment
P_4 segments
A_2 segment
P_3 segment
P_1 segment
Anterior and posterior temporal branches
P_2 segment
Basilar artery

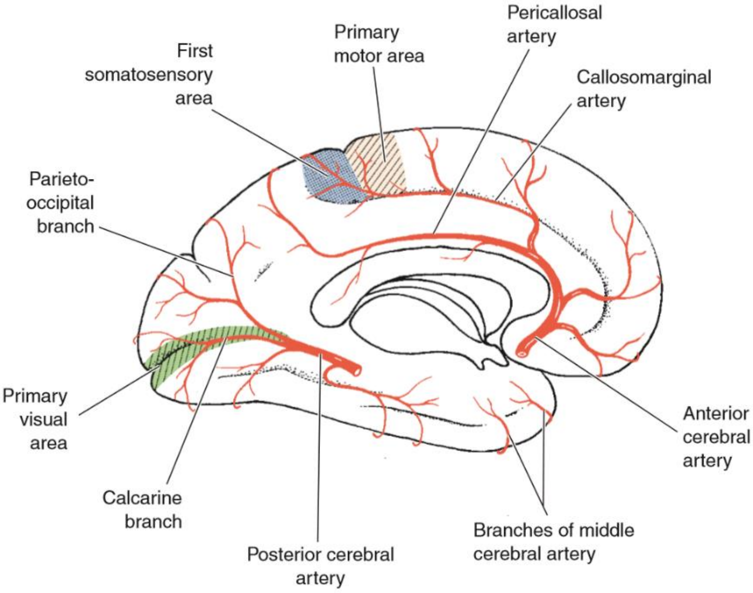

Anterior cerebral artery (ACA)
C
Border zones
Posterior cerebral artery (PCA)
ACA
MCA
Superior cerebellar artery
Middle cerebral artery (MCA)
Inferior cerebellar arteries
Lateral sulcus
C
PCA


Parieto-occipital sulcus
ACA
PCA

Supplies:

1. Basal ganglia: Head of caudate, Putamen and anterior limb + genu of Internal Capsule.
   by Medial Striate artery – branch of A2. enter through the Anterior Perforated Substance.
2. Orbital surface of Frontal lobe – Strait gyrus, Olfactory bulb, Olfactory tract.
3. Prefrontal cortex.
4. Cingulate gyrus and corpus callosum, by Callosomarginal artery.
5. Medial surface of frontal lobe (Superior Frontal gyrus) and Parietal lobes.
   - Inner part of primary somatomotor and primary somatosensory areas – the region that represent the Lower Limb and Genital.
6. Short strip on the superior part of Lateral surface.
7. Supplementary motor area.
8. Hypothalamus.

On the medial surface, Anterior branch supply the superior and anterior region, posterior supply the posterior-inferior region.

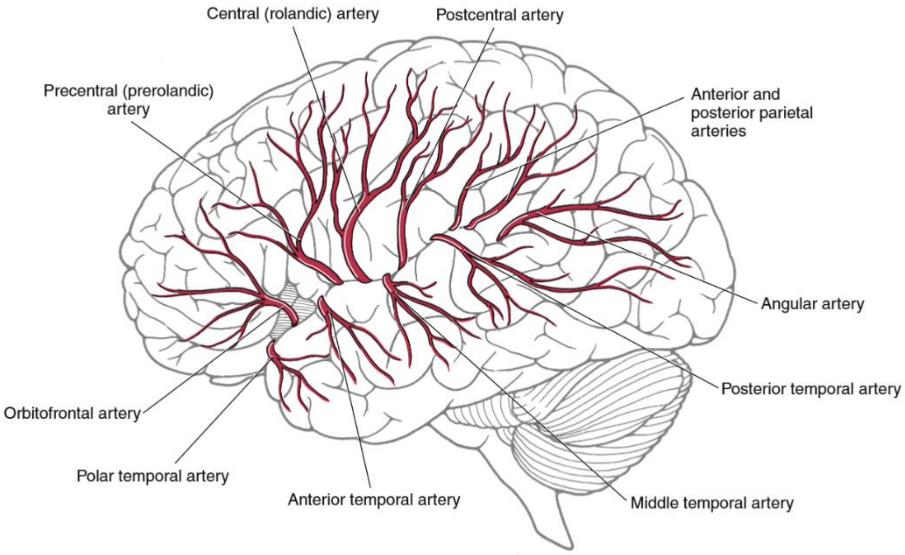

First somatosensory area
Primary motor area
Pericallosal artery
Callosomarginal artery
Parieto-occipital branch
Primary visual area
Calcarine branch
Posterior cerebral artery
Branches of middle cerebral artery
Anterior cerebral artery

Topic 17 – Demonstration of the areas of the Brain supplied by the Middle Cerebral Artery (names of branches are optional)

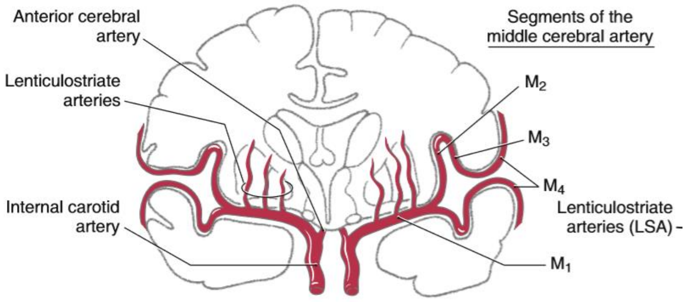
Hain's 109. Barr's 371.

- Middle Cerebral artery (MCA) – branch of ICA. usually larger than ACA. Supply mostly the lateral surface. Divide into 4 segments, M1-M4:
  M1 – from the ICA to the insula. Located in the subarachnoid space of the lateral fissure.
    Usually bifurcates to superior and anterior trunks. Supply the Temporal lobe, and
    Give Lenticulostriate artery – supply structures in the hemispheres (basal ganglia).
  M2 – Insular part – Give branches to insula.
  M3 – Opercular part – supply parts of frontal, temporal and parietal lobes that cover the insula.
  M4 – Cortical part – exit the Lateral Fissure, supply the areas of lateral hemispheres.

Lateral surface



Central (rolandic) artery
Postcentral artery
Precentral (prerolandic) artery
Anterior and posterior parietal arteries
Angular artery
Posterior temporal artery
Orbitofrontal artery
Polar temporal artery
Anterior temporal artery
Middle temporal artery



Anterior cerebral artery
Segments of the middle cerebral artery
Lenticulostriate arteries
M2
M3
M4
Internal carotid artery
Lenticulostriate arteries (LSA) -
M1

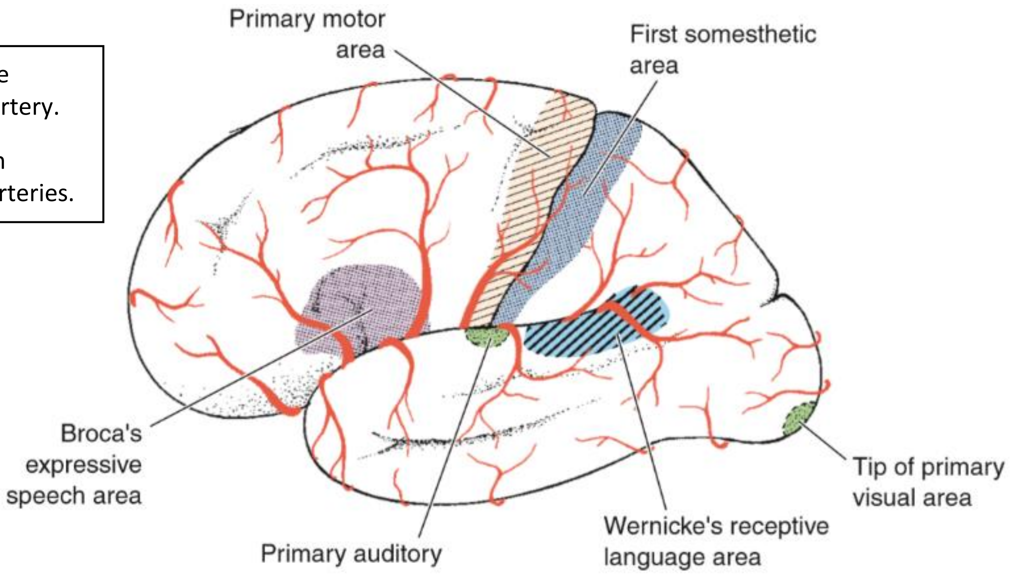
Supplies:

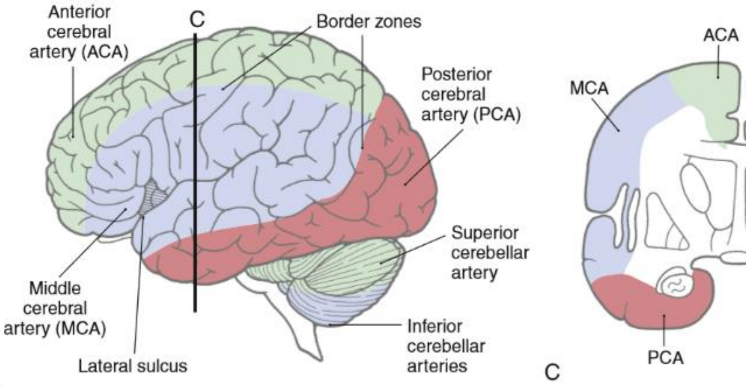
1. Insula and Areas in the lateral sulcus.
2. Opercula – areas that cover the insula – Frontal, Temporal and Parietal.
3. Parts of Frontal, Parietal and Temporal lobes:
   a. Frontal: Primary somatomotor and premotor cortex. Frontal eye field.
   b. Parietal: Somatosensory area, without the areas that represent lower limb and perineum. also the Optic Radiation that passes inside the parietal lobe.
   c. Language area – 1. Wernicke's area on the Temporal and Parietal lobes.
      2. Broca's expressive speech area on the Inferior Frontal gyrus.
4. Internal structures – Head of Caudate, Putamen, Pallidum, Internal Capsule (anterior limb and part of posterior), External and Extreme Capsules, Claustrum, Lateral Hypothalamus.
   All Through branches of circle of Willis.

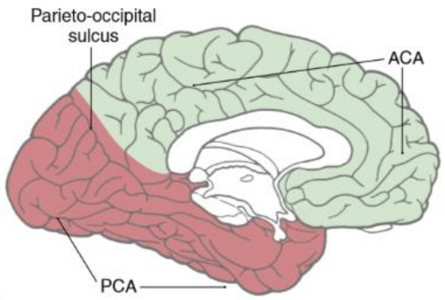
Lateral surface

Branches from the lateral fissure belong to the Middle Cerebral artery.

Branches from the side are from Anterior or Posterior Cerebral arteries.


Primary motor area
First somesthetic area
Broca's expressive speech area
Primary auditory
Wernicke's receptive language area
Tip of primary visual area


Anterior cerebral artery (ACA)
C
Border zones
Posterior cerebral artery (PCA)
Superior cerebellar artery
Inferior cerebellar arteries
Middle cerebral artery (MCA)
Lateral sulcus
ACA
MCA
PCA
C


Parieto-occipital sulcus
ACA
PCA

Topic 18 – Demonstration of the areas of the Brain supplied by the Vertebral and Basilar arteries (names of branches are optional)

Hain's 109. Barr's 371.

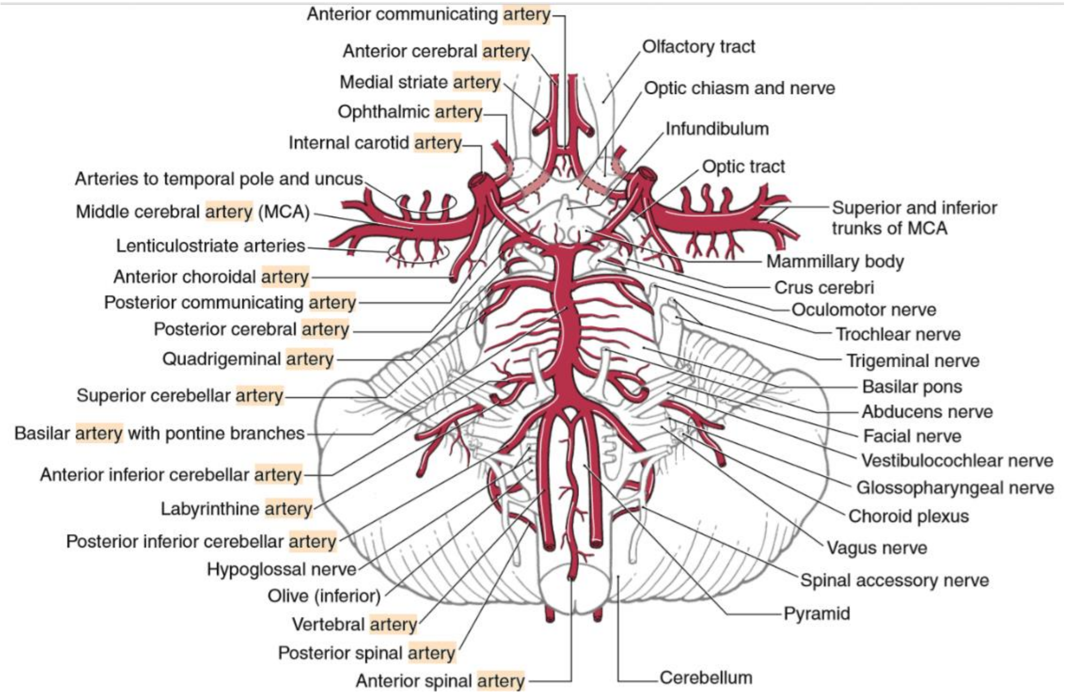
I. Vertebral artery:

- Forms the Vertebrobasilar system – main supplier of Brain Stem.
- Pathway: Has 4 parts – V1-V4.
  V1 – Originate from the Subclavian arteries, 1 on each side, then it ascends through the neck.
  V2 – ascends through the transverse foramen of vertebra C6-C2.
  V3 – penetrate the Atlantoocipital membrane, pass through C1 transverse foramen.
  V4 – enters the skull through the Foramen Magnum, cross the Dura and forms the Basilar artery. Supply the anterolateral medulla.

1. Branches:
   1. Posterior inferior cerebellar artery (PICA) – supply the medulla and choroid plexus of 4th ventricle. Located in cisterna magna.
      a. Posterior spinal artery – 2 arteries that descend to supply the posterior spinal cord and medulla. usually branch of PICA, less commonly originate from the Vertebral artery. supply the inferior medulla and the spinal cord.

   2. Anterior spinal artery – usually originate from 2 small trunks and unite to 1 at the foramen magnum. Travel in the ventral medial fissure of medulla and spinal cord. Found in premedullary cistern.

   3. Basilar artery – formed by union of the 2 vertebral arteries at the level of caudal part of pons. it travels on the anterior brain stem, at the Basilar sulcus on the Pons, through the Prepontine cistern. It gives the following branches:
      a. Anterior inferior cerebellar artery (AICA) – from the lower part of the artery, pass next to the middle cerebellar peduncle. Supply the ventral and lateral cerebellum, pons and part of the choroid plexus of 4th ventricle.
         i. Labyrinthine artery – usually branch of AICA, can also come from the basilar artery. Enters the Internal Acoustic Meatus. Supply the Inner ear.
      b. Pontine arteries – many branches that supply the pons. penetrate into pons from different points (theoretical, not seen on the specimen) – First – Paramedian branches, then – Short circumferential, lastly – Long circumferential branches that surround the pons and enter posteriorly.
      c. Superior Cerebellar arteries (SCA) – last branch. Divide to Medial and Lateral branches, that supply the Superior Cerebellum, most Cerebellar nuclei and Midbrain.
         pass under the Oculomotor nerve.
      d. Posterior Cerebral artery – from the bifurcation of the Basilar artery.


Anterior communicating artery
Anterior cerebral artery
Medial striate artery
Ophthalmic artery
Internal carotid artery
Arteries to temporal pole and uncus
Middle cerebral artery (MCA)
Lenticulostriate arteries
Anterior choroidal artery
Posterior communicating artery
Posterior cerebral artery
Quadrigeminal artery
Superior cerebellar artery
Basilar artery with pontine branches
Anterior inferior cerebellar artery
Labyrinthine artery
Posterior inferior cerebellar artery
Hypoglossal nerve
Olive (inferior)
Vertebral artery
Posterior spinal artery
Anterior spinal artery
Olfactory tract
Optic chiasm and nerve
Infundibulum
Optic tract
Superior and inferior trunks of MCA
Mammillary body
Crus cerebri
Oculomotor nerve
Trochlear nerve
Trigeminal nerve
Basilar pons
Abducens nerve
Facial nerve
Vestibulocochlear nerve
Glossopharyngeal nerve
Choroid plexus
Vagus nerve
Spinal accessory nerve
Pyramid
Cerebellum

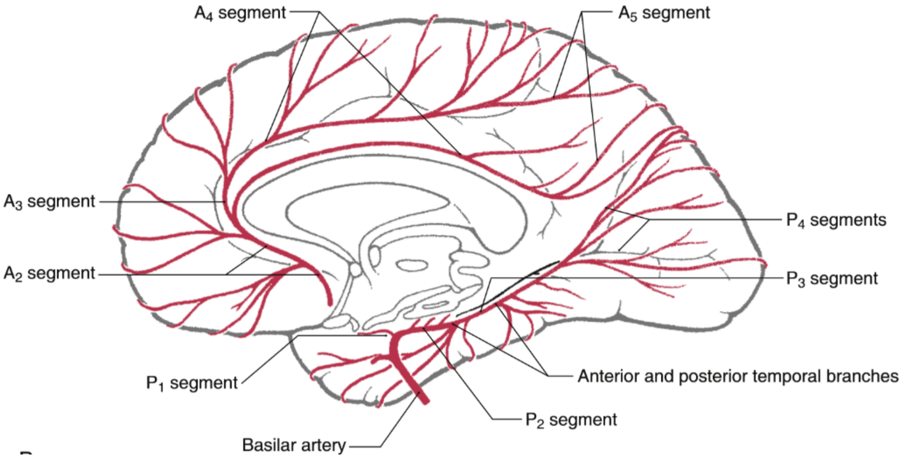
Supplies:

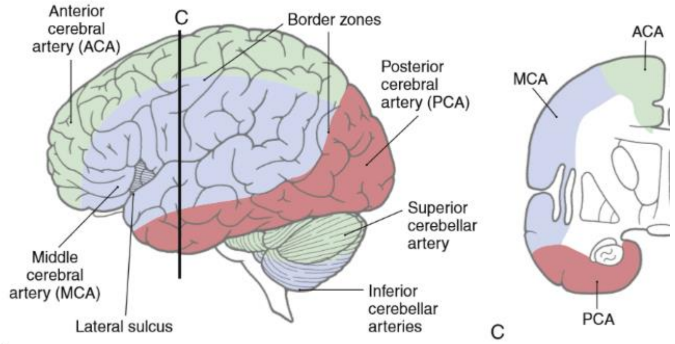
1. Anterior and Posterior spinal cord. Assisted by segmental arteries.
2. Brain stem – Medulla, Pons, Midbrain.
3. Cerebellum.
4. Inner ear – through the Labyrinthine artery.

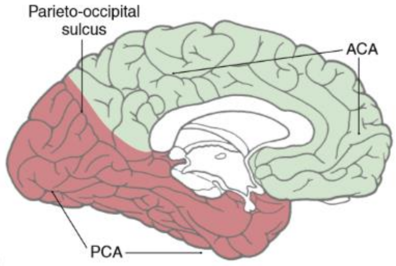
Posterior cerebellar artery:

- Originates from the bifurcation of the basilar artery.
- Supply the medial posterior surface of hemisphere.
- The Posterior Communicating artery connect it to ICA, as part of the Circle of Willis.
- Course: passes around the midbrain to the Temporal lobe. Supply the Midbrain, Thalamus, and ventral + medial surfaces of Temporal and Occipital lobe. Pass above the Oculomotor nerve.
- parts of Posterior cerebral artery – divide into 4 segments, P1-P4:
  P1 – between the basilar bifurcation to Posterior Communicating artery. Give the Quadrigeminal artery (supply the midbrain) and Perforating arteries (supply the Thalamus and other structures).
  P2 – between the Posterior Communicating and the Inferior Temporal branch. Give the Medial and Lateral Posterior Choroidal arteries.
  P3 – give the Temporal branches.
  P4 – give the Parietooccipital and Calcarine branches.

Medial surface


A$_4$ segment
A$_5$ segment
A$_3$ segment
A$_2$ segment
P$_4$ segments
P$_3$ segment
P$_1$ segment
Anterior and posterior temporal branches
P$_2$ segment
Basilar artery

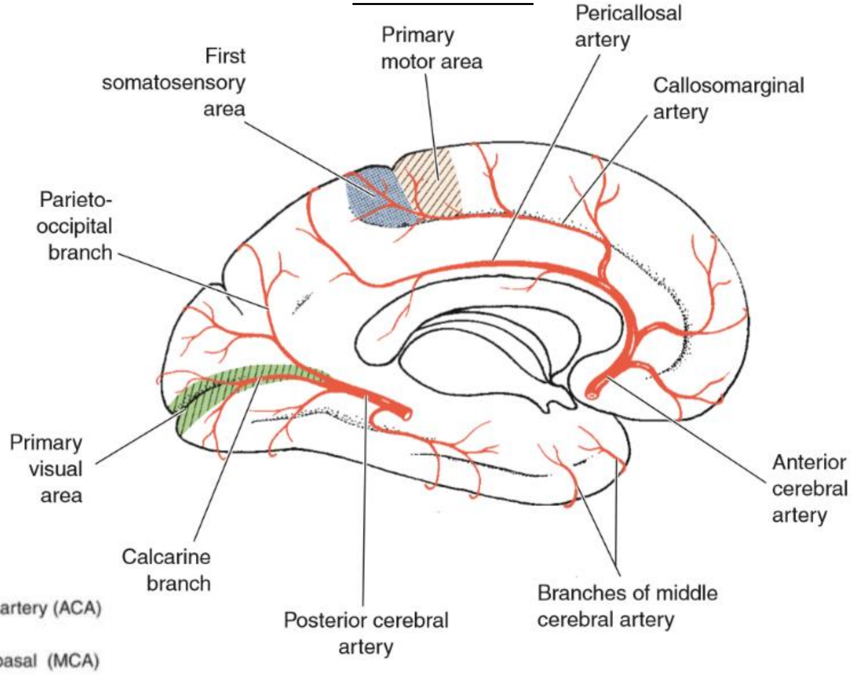

Anterior cerebral artery (ACA)
C
Border zones
Posterior cerebral artery (PCA)
Superior cerebellar artery
Middle cerebral artery (MCA)
Lateral sulcus
Inferior cerebellar arteries
ACA
MCA
PCA
C

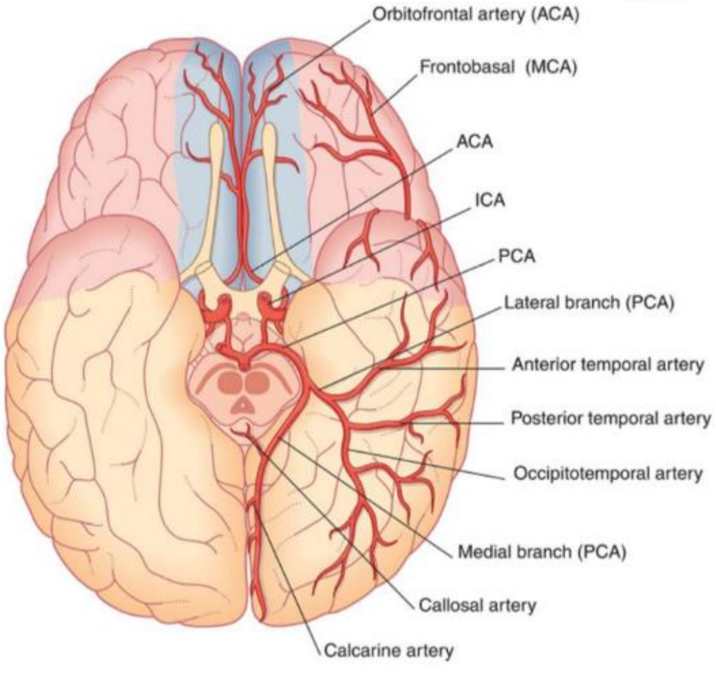

Parieto-occipital sulcus
ACA
PCA

Supplies:

1. Mostly posterior and inferior parts of the medial surface of hemisphere.
2. Also supply short strip on the lateral surface of the hemisphere.
3. Inferior surface of temporal lobe, including Hippocampus, Parahippocampal gyrus.
4. Area of Calcarine sulcus and Parietooccipital sulci – Lingual gyrus, Cuneus.
5. Primary and Association Visual cortex.
6. Posterior Choroidal artery –
    - Choroid plexus of Central part of Lateral Ventricle.
    - Choroid plexus of 3rd ventricle.
    - Fornix.
    - Posterior Thalamus.
7. Internal structures – Thalamus (posterior part), Subthalamus, Hypothalamus and Midbrain. Through branches of Circle of Willis.

Medial surface


Pericallosal artery
Primary motor area
First somatosensory area
Callosomarginal artery
Parieto-occipital branch
Primary visual area
Calcarine branch
Posterior cerebral artery
Branches of middle cerebral artery
Anterior cerebral artery


Orbitofrontal artery (ACA)
Frontobasal (MCA)
ACA
ICA
PCA
Lateral branch (PCA)
Anterior temporal artery
Posterior temporal artery
Occipitotemporal artery
Medial branch (PCA)
Callosal artery
Calcarine artery